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Observation on volcanic rocks types and alteration around Dieng geothermal field in Central Java

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ABSTRACT

Volcanic rocks around the Dieng geothermal field consists of tuff breccia, basalt, basaltic andesite, pyroxene andesite, xenolith andesite. The rocks have undergone alteration is generally weak until the total. Weak alteration generally occurs in basalt, basaltic andesite, pyroxene andesite, xenolith andesite that characterized by the appearance of chlorite-calcite-epidote as a group minerals formed prophylitic alteration at a relatively high temperature of around 230^{o}C. While the strong alteration to the total occurred in the breccia tuff that characterized by the appearance of kaolinite, montmorillonite, illite, halloysite, and cristoballite, which is included as argillic alteration, and can be formed at temperatures around 100^{o}C.

From the Northwest and North to South and Southeast, from Wanayasa, Rogo Jembangan, Jalatunda, Siglagah, Sleri, and towards Pulosari, Sikidang, Merdada and Cebong, the rocks were found change from basalt to the South and Southeast transformed into xenolith andesite (trachyte basalt xenolith, diorite xenolith?) and contain the hornblende, biotite minerals. The Changes of rocks composition is likely due to the occurrence of assimilation (?) because of the volcanic rocks penetrated sedimentary rocks of Tertiary age or other penetrating igneous rocks (?). Based on the relationship Niobium (Nb) / Zircon (Zr) * 100 with Yttrium (Y) indicate that volcanic rocks Dieng area is located in a backarc side-volcanoes.

INTRODUCTION

Indonesia has a lot of volcanic and geothermal energy sources non-volcanic, which amounts to 285 locations and approximately 29 GW potential (Geothermal Power Indonesia, 2014). Therefore, further research is needed to develop the energy potential that can be used as an alternative energy to help conserve petroleum, especially as powerhouse energy.

This paper write a review about the evolution or change of an existing volcanic rocks in the geothermal field Dieng, Central Java, which is part of one of the results of research in geology geothermal Dieng, Central Java, which aims to develop the concept of the geothermal system in Java for which data were collected from secondary data and direct field research conducted since 2011 and 2012, in Mount Argopuro East Java, in 2013 and 2014 in Dieng. Mount Slamet, Central Java (Figure 1).

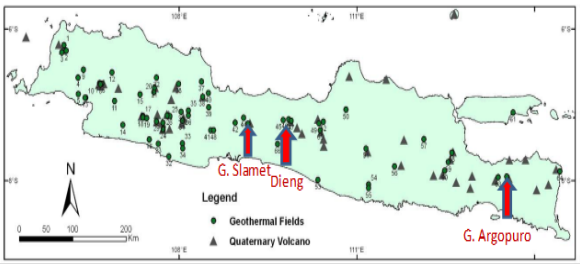


Figure 1. Quaternary volcanic map and geothermal field in Java (Taken from Setijadji, 2010).

Approximately 15 geothermal locations are in Central Java, only one is producing Dieng geothermal field with a capacity of 60 MW used for power generation (Reva Sasistiya 2008, Wahyuningsih, 2005, in the Setijadji, LD, 2010). Dieng volcanic complex including volcanic arc located on the back side of the Northwest - Southeast trending Quaternary volcanic including Sundoro cut and chipped. Dieng volcanic complex consists of two or more strato volcanoes and more than 20 small craters and cones Pleistocene to Holocene ages (Allard, et al., 1989, Siebert and Simkin, 2002, vide Setijadji, 2010). Dieng old caldera filled by a series of young cones, lava dome, crater, and several lakes. Lava flows cover a lot of the plateau, but it is not known when the formation. Volcanic activity produces rocks is andesite - riodasite (Allard, et al., 1989, Siebert and Simkin, 2002, Vide Setijadji, 2010). On the surface of the Dieng plateau are abundant geothermal manifestations that can be considered is the Dieng geothermal prospect area.

Dieng volcano caldera on pre demonstrated by the appearance of Mount Prahu, which according Boedihardi, et al.,(1991), vide Setijadji (2010), formed in the Pliocene (3.6 Ma). Then the caldera collapse during the Pleistocene (before 0.5 Ma) and filled by the eruption are monogenic. Monogenic volcanoes were extended from the Northwest - Southeast increasingly young age. The oldest caldera that last unit is Pagerkandang (0.46 Ma), while the youngest is a unit of volcanic Saroja (0.06 Ma) is dominated by phreatic eruption products and shown by the blast craters. The last eruption occurred in 1979 which issued a CO_2 (carbon dioxide). Based on carbon and sulfur isotopes, interpreted that the source of this CO_2 comes from the mantle (Allard, et al., 1989, vide Setijadji, 2010). This condition indicates that magmatic activity at Dieng complex is still active today. Dieng geothermal field associated with the oldest last caldera - old Upper Pleistocene (Pagerkandang 0.46 Ma, Pangonan - Merdada 0.37 Ma), and assumed a mature geothermal system).

METHODOLOGY

Frameworks :
Researching and studying the development of volcanic rocks in Dieng is very important to know the genesis and relation to the appearance of geothermal manifestations in the area. It required stages of research to obtain secondary and primary data. Compilation of data will be able to analyze the genesis of the volcanic rocks associated with geothermal manifestations in the area in question.

Methods :
Secondary data collection : that is to get a report earlier research on the area to be studied, as well as publications on geothermal or related to, the provision and analyzing Landsat imagery, DEM, geological and topographical maps of research areas.

Research field :
Field research includes measuring and recording the location with Global Positioning System (GPS), observation and description of outcrop geology (lithology, structural geology, hot springs, fumaroles), radon measurements with Rad - 7 to identify the permeability zone (fault or fracture zones), identify types of rocks alteration, measuring temperature and pH of hot water, making maps morpho volcano stratigraphy and structure based on Landsat imagery or DEM, rocks sampling will be used as document and analyzed in the laboratory, as well as capturing images - photos of geological data in the field to complete the report and document.

Measurement of geological structures done carefully / detailed, such as joint, especially in the vicinity of the fault manifestations, as well as geophysical measurements with magneto telluric method to determine the structure of rocks beneath the surface and which includes a water-resistant rocks (impermeable rocks) or rock cover/cap rocks, reservoir rocks, and rocks near a heat source (heat source).

Laboratory :

Petrographic Analysis :
The analysis was conducted on samples of relatively fresh rocks and alteration rocks. The results of petrographic analysis of samples of fresh rocks will get the results of the structure, texture, mineral composition, and the name of rocks. While the analytical results of alteration rocks obtained rocks traces minerals primary if they are identified, alteration minerals, the level of alteration, and the name of rocks. Alteration minerals identified will be grouped according to their own group, so it can be to determine the degree of alteration minerals formed temperature and pH (degree of acidity), and can be used as a temperature indicator that a potential source of geothermal energy, or geothermal sources were heating up or cooling conditions down, or can predict the state will be long-lived geothermal sources (under conditions of heating up) or will soon die (cooling down). Petrographic analysis carried out at the Research Center for Geotechnology LIPI.

Analysis of rocks samples by X - Ray Diffraction (XRD) :
XRD analysis was used to identify rocks-forming minerals are experiencing strong alteration, intense, or the total making it difficult to identify the constituent minerals, such as clay minerals (kaolinite, montmorillonite, illite, and so on). The presence of clay minerals would be an indication that these rocks can serve as the covering rocks (cap rocks).
This analysis was conducted in the Research Center for Geotechnology LIPI.

Chemical analysis of rocks samples :
Chemical analysis was conducted on the rocks are Major Elements (ME), Trace Elements (TE), Rare Earth Elements (REE). This analysis aims to determine the types and names contained volcanic rocks in the study area. Analysis of samples was carried out in volcanic rocks Actlab Canada. In addition to the two methods of analysis of rocks samples both petrographic and XRD, also performed other analyzes, such as hot water chemical elements - elements K, Na, Li, Ca, Mg, Cl, B, SiO2, SO4, HCO3, which is intended to determine the temperature subsurface reservoir and type of hot water. However, the data elements - chemical elements hot water is not covered in this paper.

DATA AND DISCUSSION

The data obtained in the study area include :
Morphostructure (structural geology), volcano stratigraphy, including data analysis of gravity lineament, lithology (rocks fresh and alteration), mineral alteration.

Morpho structure (structural geology) volcano - stratigraphy :
This data was obtained from the DEM image analysis Dieng area, the results show that Dieng and the surrounding area is formed by two (2) groups of rocks, ie Tertiary and Quaternary volcanic rocks of younger age can be divided into 10 (ten) rocks units, with alignment trending geological structure of East-West, Northwest - Southeast, and North-South (Figure 2).
The results showed that the DEM image interpretation of geological structures and lithology associated with the geothermal system is the structure of the Northwest - Southeast trending formed by the product of Mount Sikidang - Merdada assumed as the youngest rocks units in the composition of the volcano stratigraphy (Figure 2).

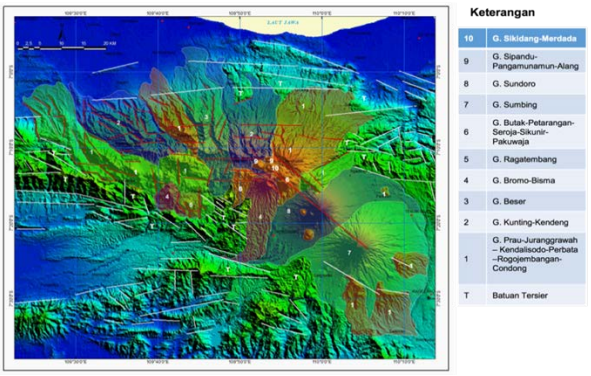


Figure 2. Morfostructures (lineaments geological structure) - Volcano stratigraphy (Based on DEM image analysis, Haryadi P., 2013).

Structural Geology:
Dieng regional geological structure can also be known from chart patterns Rosset and straightness of gravity measurements (Ahmad Fauzi, 2013), which shows the direction of North - East, West, East, and North - South. While the general direction is North-East are still similar to the general direction of Sumatra, and the manifestation of this control occurs in Dieng evidenced by the appearance of a row of hot springs in Wanayasa (Tempur village) which is directed N288^{o}W or around Northwest - Southeast (Photo 1).

Photo 1. Rows of hot springs trending approximately N288^{o}W or Northwest - Southeast, located on Tempur 3, Wanayasa.

Lithology :

Lithology (rocks) of Dieng and surrounding area consists of sedimentary rocks of Tertiary and Quaternary age volcanic rocks (Condon, et al., 1996). But volcanic rocks more dominant in the study area, which consists of andesite, basalt is generally in the form of lava, and pyroclastic rocks (tuff breccia), Photo 2 a,b.

Results petrographic analysis of a number of volcanic rocks samples taken from the West is Wanayasa, Rogojembangan eastward – Sikidang, Pulosari area, and from the North is Candradimuka (CDM) and Siglagah to the South and Southeast (Figure 3 and Photo 3) shows the area Merdada, Telaga Warna and Cebong show changes in the mineral composition of rocks are quite significant, so it can affect the properties and naming rocks. The volcanic rocks of the West to the East, and from North to South and Southeast of change of base rocks (basalt) to the intermediate (andesite), while in the South and Southeast of rocks xenolith andesite (trachyte basalt xenolith, diorite xenolith) and containing minerals hornblende and biotite (Figure 3). The named of volcanic rocks of the location investigation based on classified of Williams, et al., 1954. Setijadji (2010) mentions that the activity at Dieng volcano produces rocks are andesite - riodasite, on that basis it can be assumed that a change in the composition of the rocks of basaltic xenolith andesite be Dieng and the surrounding area may be caused by the process of assimilation between the rocks that breakthrough the rocks was intruded.

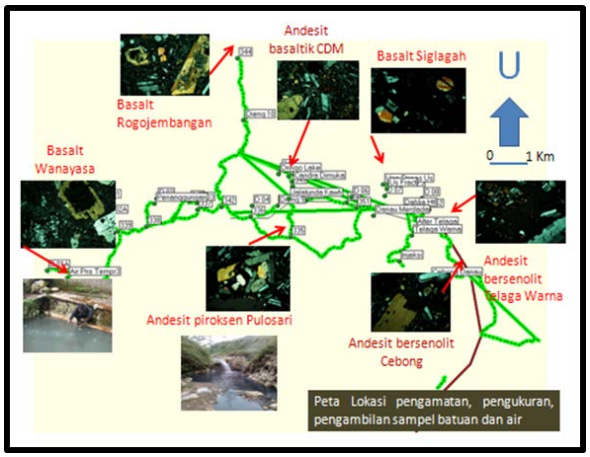


Figure 3. Sitemap geological observation, measurement, sampling rocks and water

Based on the results of chemical analysis of samples of volcanic rocks of the study area using relationship diagrams SiO_2 and K_2O are made Pecerillo and Taylor, 1976, the name of volcanic rocks that formed in Dieng and surrounding areas, can be determined as basaltic andesite and andesite containing Potassium (K) is quite significantly with the concentration range of 1.5 -3% (Figure 4), and based on the correlation diagram Y (Yttrium) and Nb Zr_{*100} (Zulkarnain, I., 2001), the volcanic rocks in the study area including the back arc side type of volcanic (Figure 5).

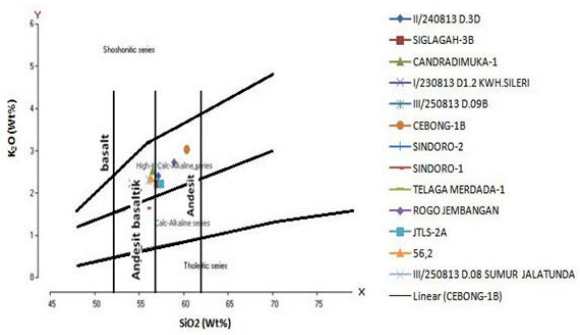


Figure 4. Classification Dieng volcanic rocks and the surrounding area by using the classification diagram of volcanic rocks that made Pecerillo and Taylor, 1976, based on the content of SiO_2 vs. K_2O

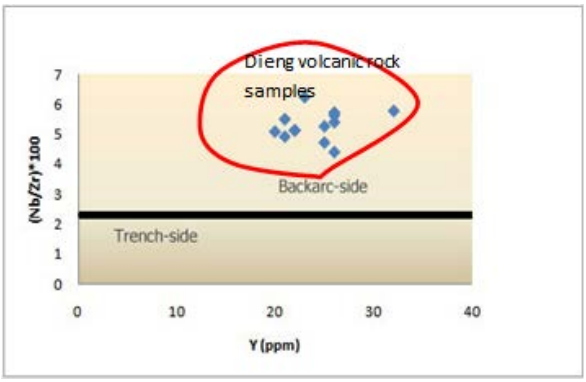
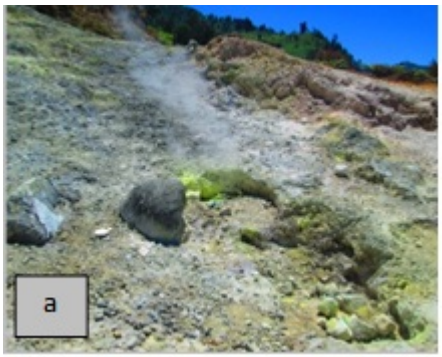


Figure 5. By using elemental relationship diagram Y (Yttrium) Nb Zr_{*100} made by Zulkarnain, I., 2001, the position of volcanic rocks in the Dieng area lies in Backarc-side volcanic

Rocks are close to the geothermal manifestations generally have alterated, mainly occurring in lava basalt, andesite and tuff breccia. Alteration type is argillic and prophylitic among others. Argillic alteration occurs in tuff breccia rocks are around the geothermal manifestations, such as in craters Sikidang, Sleri, Siglagah, Candradimuka, Wanayasa. Argillic alteration of which is indicated by the presence of the mineral montmorillonite, kaolinite, illite, halloysite, and is often associated with silica minerals (quartz, cristobalite, opal), sulfur levels of low to very high. Argillic alteration characterized by minerals formed at relatively low temperatures of around 100°C, making it less acidic potential for geothermal development (Izawa, 1993). While the prophylitic alteration generally occurs on basaltic lava, basaltic andesite, andesite, which is characterized by the appearance of the mineral chlorite, calcite, and epidote. But not all of these minerals can be found in full, only chlorite generally always arises. According to Izawa (1993), minerals - mineral prophylitic groups, especially epidote which can be formed at temperatures around 230^{o}C is a mineral that is the potential for geothermal development.

The relationship between the presence of volcanic rocks, the type of alteration and geothermal manifestations in the study

area can be explained as follows. Basalt rocks, basaltic andesite, andesite is generally found in the western and northern parts of the study area, generally experience prophylitic alteration, which is characterized by the appearance of the mineral chlorite, calcite, epidote. In this prophylitic alteration zones, geothermal manifestations generally still active, which is indicated if the emergence of hot springs and fumaroles as found in Wanayasa, Candradimuka, Siglagah, Sleri, Pulosari. While more and more to the south and southeast of the rocks is a tuff breccia, xenolith andesite (xenolith bearing andesite) and andesite containing hornblende and biotite, which develops alteration is argillic type characterized by the appearance of kaolinite, montmorillonite, halloysite, silica, with many crystal - sulfur crystals. In the argillic alteration zone geothermal manifestations are found in small amounts of hot water, mud pool and solfatara as obtained in Sikidang. Whereas in other places are at Merdada Lake, Pengilon Lake/ Telaga Warna, Cebong Lake, geothermal manifestations (hot springs, fumaroles) does not seem show activity. Based on the position of volcanic rocks, alteration types and manifestations of geothermal in the area of research, it can be assumed that if the alteration of rocks that occur more acidic then geothermal activity will decrease, because the hot water temperature has lowered due to the possibility of closing the manifestation by impermeable rocks (impermeable).



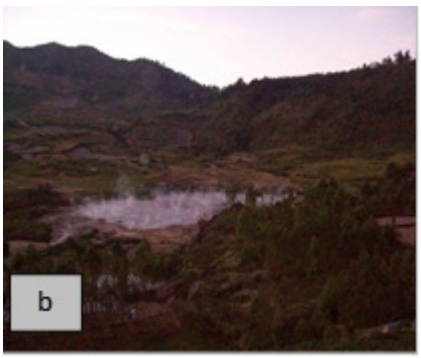
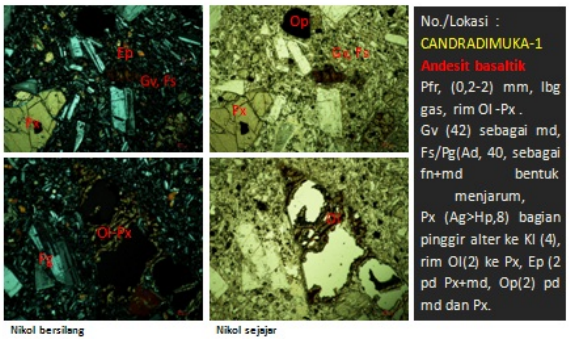
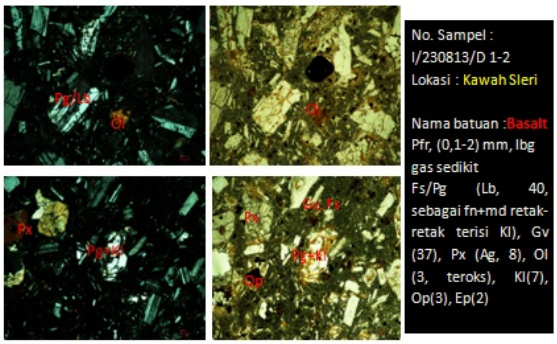


Photo 2. Appearance of breccias tuff altered found of sulfatara indicated by sulfur crystals are still hot (a), and a mud pool (b) in the crater area Sikidang



(a)



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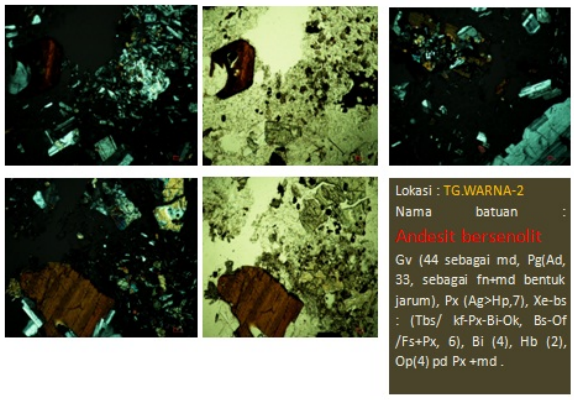

(c)

(d)

Description: pfr - Porphyritic, fn - Phenocrysts, md - Groundmass, LBG gas - gas pit, Xe - Xenolith, Xe_Bs - Xenolith Basalt, Hb - Hornblende, Fr - Rocks Fragments, Gv - Volcanic Glass, Pg - Plagioclase, Ad - Andesite, Lb -

Labradorite, Fs - Feldspar, Px - Pyroxene, Ag - Augite, Hp - Hypersthene, Di - Diopside, Ol - Olivine, Kl - Chlorite, Ep - Epidote, Bi - Biotite, Si - Silica, Ks - Calcite

Photo 3. (a)-Photomicrography of Andesite basaltic at Candradimuka 1 (CDM-1), (b)-Basalt at Kawah Sleri, (c)-Xenolith bearing andesite at Telaga Warna, (d)-Xenolith bearing andesite at Telaga Cebong.

CONCLUSION

Dieng geothermal systems in the region are multi-cone (cone) volcanic craters have formed as a result of a phreatic eruption. The system is controlled by a structure under which major depression is estimated to be occupied by a heat source such as magma pockets. Flow volcanic rocks (volcanic flows) in the form of lava basalt, basaltic andesite, and andesite generally have alterated and prophylitic zones forming a positive indication for the formation of geothermal systems. This is partly reflected by the temperature of formation of the minerals in the prophylitic alteration zone is relatively high so that a proof of the existence of magmatic activity that can act as a heat source. The results of petrographic analysis of a number of volcanic rock samples taken from the West is Wanayasa, eastward of Rogojembangan - Sikidang Pulosari area, and from the North is Candradimuka (CDM) and Siglagah to the South and Southeast regions showed changes in tadpole Merdada and mineral composition rock, so it can affect the properties and naming rocks. The volcanic rocks of the West to the East, and from North to South and Southeast of change of base rock (basalt) to the intermediate (andesite), while in the South and Southeast of rock xenolith andesite (trachyte basalt xenolith, diorite xenolith) and containing minerals hornblende and biotite (Figure 3. Changes in the composition of basaltic rocks into xenolith bearing andesite in Dieng and surrounding areas may be caused by the process of assimilation between the rocks break through the rock was intruded. Based on the relationship between Y (Yttrium) Zr and $Nb_{*\ 100}$ Dieng volcanic rocks area, the Dieng volcano located on the back side volcanic arc

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