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GEOTHERMAL PROSPECT ANALYSIS BASED ON GEOMORPHOLOGY AND ALTERATION OF UNGARAN GEOTHERMAL FIELD

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Abstract
Ungaran is one of geothermal fields in Java Island. Geomorphologically, the prospective areas is located in Mt.Ungaran, Central Java. This volcano is active but it is already in post volcanism stages, indicated by eroded, gently slope topography in its summit or slopes. This geomorphological characteristics indicate moderate stage of geothermal prospect. This area consist of variable volcanic rocks, show the hydrothermal alteration. The alteration type usually occur in argilitization - chloritization types with have more altered in the depth. This modium alteration stage indicate moderate to high geothermal prospect, supported by less intensive manifestation of outcrop's alteration.

Introduction

This paper wrote as descriptive analysis of Gedongsongo geothermal prospect areas in Central Java. The geomorphology and rock characteristics in this geothermal fields has been described to know about the geothermal condition of geothermal stage and prospect. The analysis of general characteristics of geothermal has been carried out based on secondary data, supported by author's experiences in some geothermal projects in this area.

The geothermal is well known as alternative energy resource in Indonesia right now. This resource may be main resource in the future, as the most increasing of demand of energy supply. Geothermal itself, affords to alternate others non renewable energy sources because of its characteristics such as renewable, sustainable and friendly to our environment.

One of the most popular region of geothermal in Indonesia is Java Island. This island has many geothermal spots, all of them are in volcanic areas. There are active volcanoes in Central Java which have potential of geothermal resources, one of them is Ungaran volcano. This volcano yield Gedongsongo prospect area. This article tells about the geothermal characteristics especially on geomorphology and alteration of rocks. The descriptive article should be important to make better understanding of prospect geothermal resource.

Geomorphology

Ungaran geothermal field is located in Ungaran Quaternary active volcano, which most geothermal manifestation located at Gedongsongo, in the southern slope of the volcano. This geothermal field is formed by Ungaran volcano activities. Ungaran volcano still show good shape of cone, but slight eroded on its slope. This eroded morphology sometimes can be seen in valley of gullies. The morphology of Ungaran body seem smaller relatively with rather steep, better cone shape of peak. The morphology of the Mt. Ungaran can be seen in Figure 1 below.

Stream erosion usually refer to area stage. According to Van Zuidam (1983), stream erosion produces many types of valleys, most of which exhibit topographic features revealing lithology, geologic structure, conditions of erosion and the geomorphologic history or the area during erosion. The valley form types can be distinguished as broad, gently sloping and shallow valleys in foot slope of Mt. Ungaran, indicate maturity stage of morphology.

a. b.

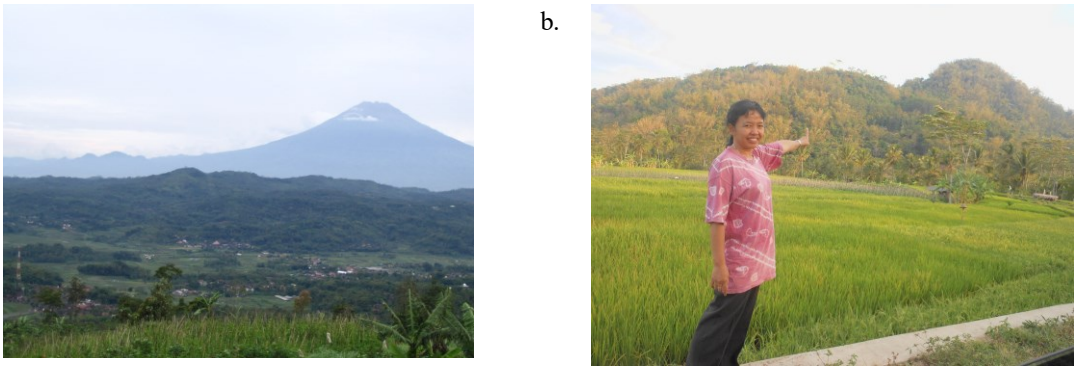

Figure 1. Morphology of Ungaran volcano.
Source: a. Energy & Mining Dept. of Central Java – Geomap, 2005.
b. The author, 2013.

Whereas, V-shaped valley, which can be either wide or more narrow shaped usually can be found at summit to the upper part of Ungaran body, indicate young stage of morphology. Young to maturity stage of geomorphology indicate the moderate prospect of geothermal.

Like other prospect areas, Gedongsongo geothermal system also supported by rim structure. This collapse structure should be easier known from remote sensing. Eruption center of its mountain is lied in collapse structure (Figure 2). This structure looks like cross faults made round shape, formed rift fault system which opened northeastward (to Mt. Ungaran peak direction). The activities of Mt. Ungaran were controlled by this collapse structure. The other structures appearance are northwest – southeast and southwest – northeast faults. The north – south direction fault passed Gedongsongo area is predicted to control geothermal manifestation in this region.

Litology

The Ungaran geothermal system consists of Pleistocene rocks in the upperpart of geothermal area. Stratigraphy of volcanic products may be take role as reservoir and cap roks of geothermal. The heat source of Gedongsongo prospect is magma chamber of active Ungaran Mountain. This heat had produced alteration rocks in the basin.

The reservoir rock should be porous, permeable rock, meanwhile, cap rock must be impermeable one. Types of geothermal reservoir in Java usually are volcano types. According to Sudradjat (2009), volcanic facies as the reservoir in Java Island combined with the ancient diatrema and local faultings. The volcano type of geothermal potential refer that the steam related to the old volcanoes at the fumarolic or solfataric stage in the Quaternary volcanic belts. This type mainly distributed in the Quaternary volcanic belt

in Java. Reservoir rock of Gedongsongo area supported by old pre caldera volcanic and sedimentary rocks of Kerek and Kalibeng Formation. Young Quaternary volcanic rocks, especially lava, usually act as cap rocks. Young volcanic rocks of post caldera activity of Mt. Ungaran well functioned as cap rock of Gedongsongo geothermal system.

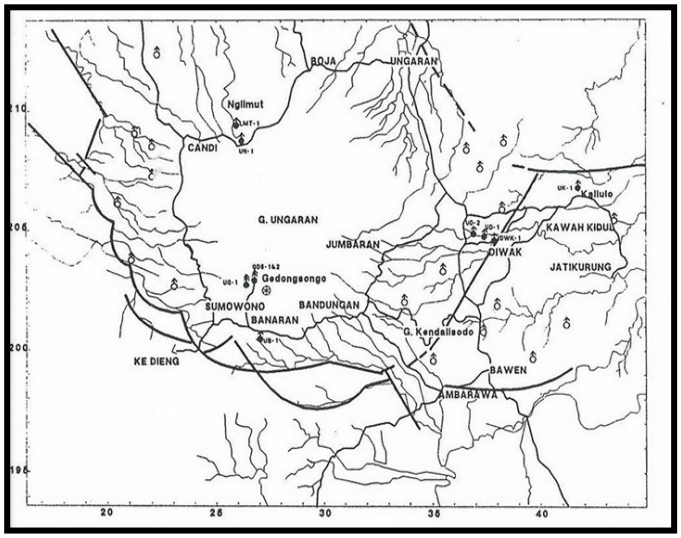

Figure 2. Manifestation map of Ungaran geothermal area (Pertamina, 1994). The collapse structure indicated by cross curves around the peak.

Alteration

As the manifestation appearance there are some alteration rocks of outcrop in Gedongsongo and surrounding area. The alteration seems not intensively, only showed at several locations (Figure 3). The alterations rocks are usually outcropped around fumarole location.

Figure 3. The alteration volcanic rocks at Gedongsongo area, show yellowish brown or black in color with sulfuric coating (upper). Alteration rocks around hot spring and fumarole (lower).

Around fumarole, there are some small hot springs with yellow sulfuric deposit. The alteration rocks usually located in river valley, yellowish brown to greyish black

in color. Their alteration type usually include in argilitization type. These alteration fenomena occur in andesitic lava and breccia (Disbang Jateng – STTNAS, 2004). They can be obviously observed from the color and petrophysic. The petrophysic characteristic usually show soft, uncompacted, weathered condition of outcrops. Sometimes, the odor of sulfur strong smelled at the place surrounding the alteration rocks.

The alteration process not only showed on the surface. There are some alteration occur in the depth, even more intensively. Geoservices (1992) wrote that there are rocks which alteration intensity and level increase to the depth. The strongest intensity and alteration level occur in depth of 447 – 500 m which 50 – 75 % alteration intensity indentified by chlorite increasement until 25% and secondary quartz reach 12%. This data show that in this interval depth there is higher temperature compared with upper depth. The alteration types found as argilitization and chloritization types.

Further, Geoservices (1992) also remark that there are socandary and primary biotite minerals can be noticed from petrographic analysis. This fact can be interpreted that geothermal process in this area occur higher temperature of thermal periode in the past. The temperature measured now is 52^{o}C in depth of 500 m based on temperature gradient measurement.

Energy & Mining Departement of Central Java and C.V. Geomap, 2005 report some alteration rocks from Gedongsongo area. From petrographic analysis, there are some rock samples show variable alteration, usually have weak to strong alteration intensity (Table 1). The rocks vary in altered diopsid andesite, altered biotite andesite, altered hornblend andesite and altered augit andesite. The altered minerals commonly show chlorite, clay mineral, iron oxyde as well as calcite, occured from replacement process. This alteration process was influenced by geothermal condition.

On the other hand, Listyani & Budiadi (2006) said that alteration rocks at Gedongsongo area consist of volcanic breccia and igneous rock which commonly have argilitization to chloritization types. Alteration minerals came from replacement process and producted secondary minerals such as clay minerals, chlorite, iron oxyde, pyrite, biotite, carbonate minerals and samll abundance of quartz. The alteration intensity vary from low (20%) until high (85%).

Based on Hayashi classification (1973, vide Listyani & Budiadi, 2006), Gedongsongo has alteration type II, sub-type IIb – IId or IVc, with formation temperature higher than 230oC in sulfuric weak to strong acid solutin condition. By considering altered minerals variaty to depth therefore the research area at least has three alteration zones, which each zone is dominated by secondary minerals such as clay minerals, chlorites and ore minerals.

In fact, based on the intensity of alteration, the geothermal prospect can interpretated occur in moderate to almost high potential. But, the alteration on surface less supported high level potential of this research geothermal field. Alteration manifestation on surface looks not occur on so wide area, controlled by geological structure near fumarole.

Table 1. Result of petrographic analysis of rocks at Gedongsongo.

No	Sample	Alteration Intensity (%)	Name of Rock (Williams, 1954)
1	STA 1	75	Altered biotite andesite
2	STA 6	85	Altered biotite andesite
3	P7	85	Altered hornblend andesite
4	P10	40	Altered biotite andesite
5	STA 10	85	Altered biotite andesite
6	P16	45	Altered biotite andesite
7	P17	50	Altered hornblend andesite
8	P19	25	Altered biotite andesite
9	P20	80	Altered augit andesite
10	P22	50	Altered biotite andesite
11	P26	40	Altered hornblend andesite
12	P27	80	Altered biotite andesite
13	P29	85	Altered biotite andesite
14	P30	85	Altered andesite
15	P31	85	Altered biotite andesite
16	P32	65	Altered biotite andesite
17	P34	85	Altered biotite andesite
18	P36	65	Altered augit andesite
19	P37	65	Altered biotite andesite
20	P50	50	Altered biotite diorite

Based on the data described above its can be known that alteration process occur from the depth until surface. The intensity and level usually catagorized as moderate condition. This condition support geothermal potential which not high prospect. This condition require more supporting data to know geothermal prospect more accurate.

Conclusion

There are some descriptive characteristics of geomorphology and petrology of rocks in Ungaran geothermal prospect area. The characteristics can be explained as below.

1. Geomorphology of Gedongsongo geothermal area shows the old Quaternary volcano which considered as potential geothermal. The volcano has been in the post volcanism indicated by eroded morphology on the slope of volcano. This characteristic usually refer to moderate potential of geothermal energy. Young to maturity stage of geomorphology of Mt. Ungaran also indicate the moderate prospect of geothermal.
2. The Gedongsongo geothermal system is supported by reservoir rocks mainly composed by old Ungaran Quaternary volcanic rocks and Kerek/Kalibeng Tertiary volcanic/sedimentary rocks; and, the cap rocks usually formed by young Ungaran volcanic rocks. These litology sometimes show alteration

rocks both on the surface or in the depth.

3. The manifestation of geothermal is shown by alteration rocks both on the surface as outcrops and rocks in the depth, with weak to high alteration intensity, strong supported by attendance of secondary minerals. The alteration fenomena strong the moderate to high potential of Ungaran geothermal prospect.

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