Soil and Fluids Geochemistry Analysis to Determine Non-Volcanic Geothermal Potential, Case Study of Bayah, Banten, Indonesia

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SUMMARY

Bayah is an area with complex geology located administratively in Lebak District, Banten Province, approximately 80 kilometers at the southwest of Jakarta. In this area, four geothermal manifestations were found in the form of four hot, also 139 soil samples were sampled. This study aims to determine the non-volcanic geothermal potential of the Bayah area. The method used in this research is analysis of fluids geochemistry that is determine type of fluids, origin of fluids, and fluids maturity, Also the calculation of the estimated reservoir temperature. After that, a map based on soil chemistry data which are Hg distribution anomalies in the soil is made.. Analysis of Fault and Fracture Density were also carried out to determine the fracture density developed in the study area. The result of this geothermal prospecting zowere collected to produce the real prospect area. The result of this study shows that the geothermal prospect zone in the Bayah region is located e in the southeast of the research area, precisely around theAPPC-1, APPC-2, and APPC-3 manifestations, having an area of about 3,3 km^2. Based on the geothermometer calculation, geothermal potential of Bayah area has medium enthalpy with reservoir temperature around 138-165 ºC. The resources calculated in this study were 33 MWe.

Key words: Soil Geochemistry, Fluids Geochemistry, Non-Volcanic Geothermal, Geothermal Potential, Bayah.

INTRODUCTION

The research area is located in Bayah district, Lebak district, Banten province, Indonesia (Figure 1). Geothermal exploration in this area has been conducted by the Geological Survey Team from PSDG in 2011. This survey consisted of sampling of mercury in the soil and sampling of geothermal manifestations. However, the survey of geothermal prospectivity has not been analyzed based on correlation of soil geochemistry, fluid geochemistry, and fracture density anomaly analysis.

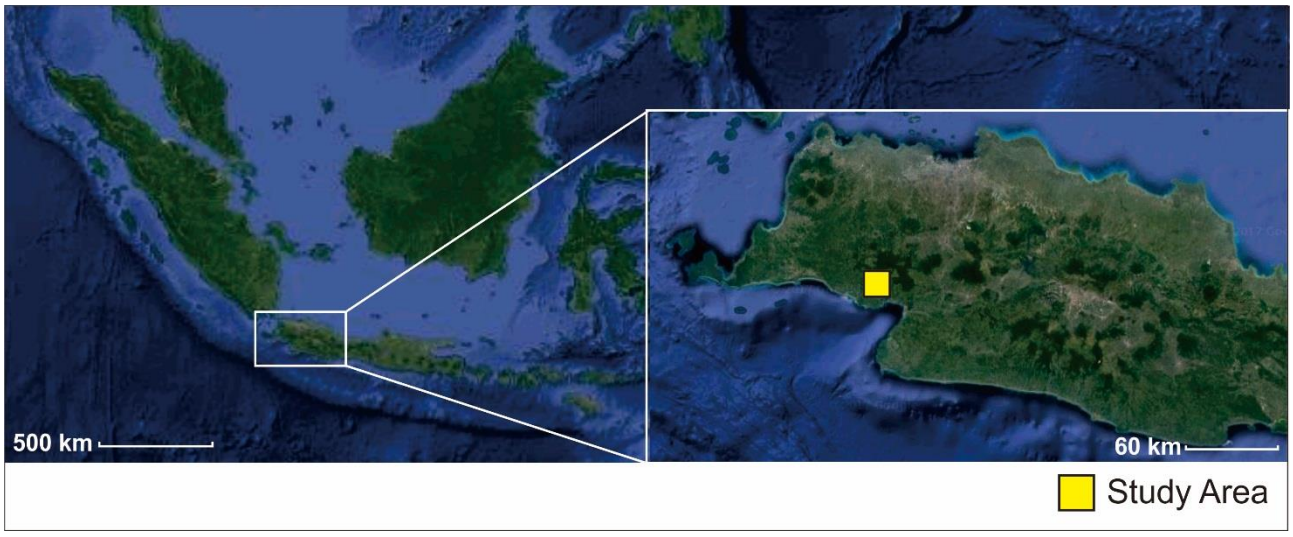

Figure 1: Study area.

Soil and Fluid are important objects in geothermal exploration activities, these two objects have their respective roles to determine the geothermal potential of a prospect area. The content of mercury in the soil is used for the exploration of geothermal potential. This analysis of mercury data can improve understanding of potential prospect areas (Varekamp and Buseck, 1983), define drill targets (Varekamp and Buseck, 1983), and determine geothermal prospects (Matlick and Shiraki, 1981).

METHOD

Hg anomalous distribution map was used in soil geochemical analysis and map of fracture density anomaly which waslater compiled to see the potential of geothermal prospect area of bayah. Geochemical fluid analysis is used to determine the type of fluid water, fluid origin, fluid maturity, and to determine the reservoir temperature estimation (Nicholson, 1993). From the mercury distribution map as well as the fracture density map we obtained the prospect area of Bayah geothermal area. From the calculation of geothermometer we will get reservoir temperature.

RESULTS

Geothermal Hot Springs Manifestations

- Pamancalan-1
  Hot water is located in the Sukamulya Village, Cibeber District, Lebak regency is on the edge of the river, out through the rock gap and spread along the 20 m. Pamancalan-1 has clear and odorless color characteristics, with 0.2 l / s discharge.
- Pamancalan-2
  Pamancalan-2 is located in Sukamulya Village, Cibeber District, Lebak District, located 50 m across from Pemancalan-1 location out through rock gap. This hot water is clear and odorless, with a discharge of 0.2 l / s.
- Pamancalan-3
  Pamancalan-3 is located in the Village Sukamulya, Cibeber District, Lebak regency, located on the edge of the river Pamancalan. This hot water is clear and odorless, with a discharge of 0.2 l / s.
- Citando
  Citando is located in Senang Hati Village, Malingping District, Lebak District, in the form of hot water bath, has clear color, there is brownish iron oxide deposits, sinter carbonate, with 0.2 l / s discharge.

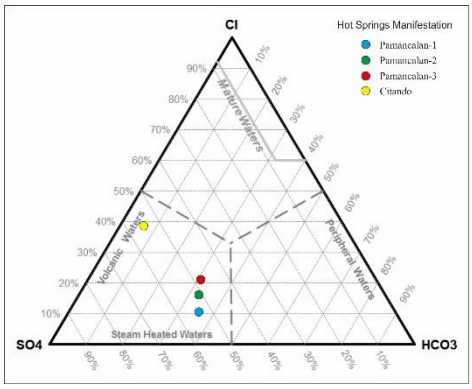

Figure 2: Result of Cl-SO_4-HCO_3 diagram plotting.

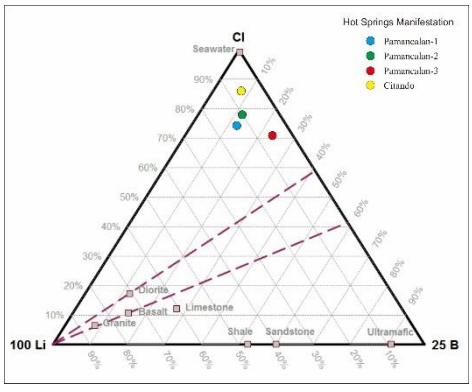

Figure 3: Result of Cl-Li-B diagram plotting

Type of Fluids

Cl-SO4-HCO3 diagram shows the comparison of the relative ratios of Cl, SO4 and HCO3 reflecting the origin of the fluid. The soluble element or component of a surface manifestation is reflected by the relative concentrations of Cl, SO4 and HCO3 anions, derived from magmatic volotiles such as HCl, H2S, SO2 and CO2. Ploting on this diagram is done to know the type of each fluid manifestation.

Based on the result of plotting it is found that the manifestations of Pamancalan-1, Pamancalan-2, and Pamancalan-3 have Sulfate-Bicarbonate water type. This shows that this manifestation is close to the Upflow zone but the fluid manifestation has been partially mixed with meteoric water or water formation. Meanwhile, Citando manifestations have water type Sulfate-Cloride, this shows that this manifestation is more towards the Outflow zone, because Cl enrichment indicates deep geothermal system. In addition, judging from the location of the manifestations are also far from the research area.

Origin of Fluids

Cl-Li-B diagram is a relative comparison diagram between Cl, B, and Li. This diagram shows the origin of fluid and deep process (Buenviaje, 1991).

Based on the results of ploting on the Cl-Li-B diagram it is found that all the manifestations are at relatively equal value, it shows that all these manifestations come from one same reservoir as well as the same lithology.

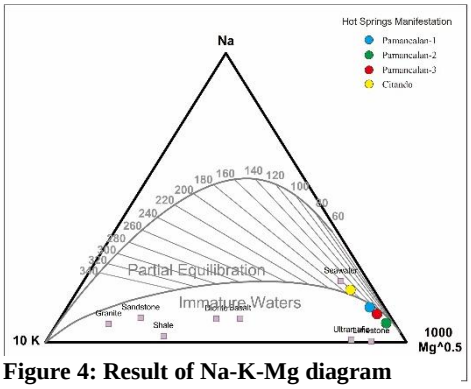

Figure 4: Result of Na-K-Mg diagram plotting

Fluids Maturity

Na-K-Mg diagram shows the comparison between the Na, K, and Mg cations present in the geothermal fluid. The more Mg element less mature, because this element is commonly found in formation waterand also meteoric water.

Based on the result of ploting on the Na-K-Mg diagram it is found that the samplesof Pamancalan-1, Pamancalan-2, Pamancalan-3 are in the immature water zone, while the manifestation of Citando is in partial equiblium.

Manifestation	Na/K Fournier 1979	Na/K Giggenbach 1988
Pamancalan-1	140	160
Pamancalan-2	141	161
Pamancalan-3	138	158
Citando	146	165

Table 5: Result of Geothermometry Calculation

Geothermometry Calculation

Geothermometer calculations are performed to determine the suspected reservoir temperature. Two geothermometers were calculated, namely Na / K Fournier (1979) and Na / K Giggenbach (1988).

From the calculation results obtained that the geothermal reservoir temperature Bayah region around 138-165 ºC, and categorized by medium heat enthalpy system.

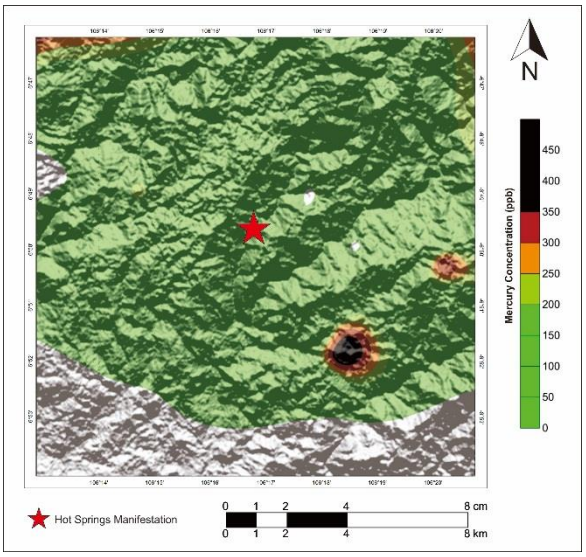

Figure 6: Mercury Anomaly Distribution Map

Mercury Anomaly

The mercury anomaly distribution map is used to determine the potential geothermal area. Mercury Consentration in Soil influenced by atmospheric parameter. Most soils retain Mercury by formation of chelates, by absorption on clays, or by ion exchange. Soil characteristics like pH, clay content and organic content influence the Hg distribution in soils, but geothermal activity introduces Hg in sufficient amounts to overwhelm local background variations (Varekamp and Buseck, 1983).

The distribution map of mercury anomaly is made from ploting mercury content value in soil of 139 point of soil samples. Based on the mercury anomaly distribution map it was found that mercury anomalies occuredat three location points (with anomalies over 300 ppb), ie in NW, East, and SE areas of study, with peak being in SE research area.

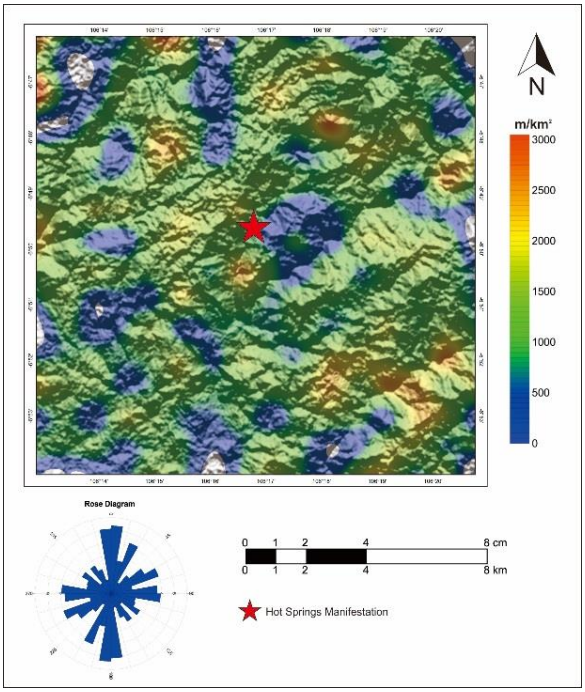

Figure 7: Fault and Fracture Density Map (Modified from Sentosa et al.,2017)

Fault and Fracture Density Map

The lineament density map shows an uneven distribution of density in the study area. Areas with the highest lineament density are in the southeast of the study area with red to orange zones. While the geothermal manifestations obtained in the study area are in the green zone indicating medium density.

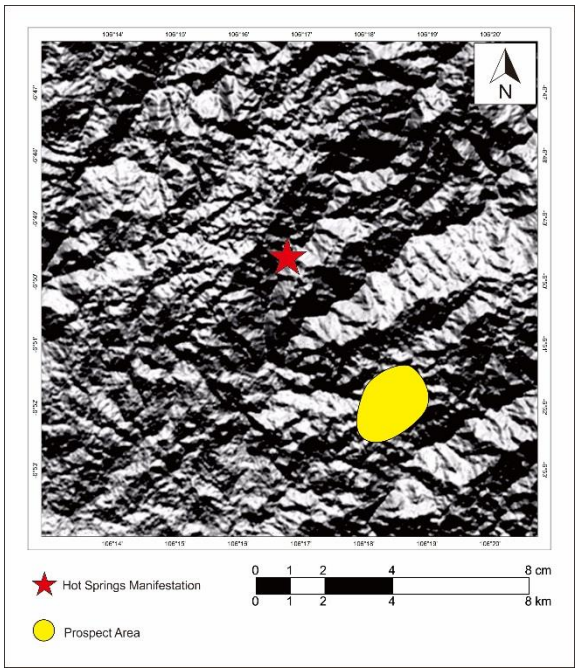

Figure 8: Prospect area of Bayah Geothermal Area

Bayah Geothermal Potential

Bayah geothermal prospect area is determined using compilation of mercury anomaly map and density map, and the result is an area with 3,3 km^2 based on high density zone and high mercuy anomaly. As for the value of geothermal potential in research area, speculative rescource calculation is used based on the prospect area and reservoir temperature. The result is geothermal potential value of prospect area that is 33 MWe.

CONCLUSIONS

The result of this study shows that the geothermal prospect zone in the Bayah region is located in the southeast of the research area, precisely around APPC-1, APPC-2, and APPC-3 manifestations, having an area of about 3,3 km^2. Based on the geothermometer calculation, geothermal potential of Bayah area has medium enthalpy with reservoir temperature around 138-165 ºC. The resources calculated in this study were 33 MWe.

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