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INTERPRETATION OF ALTERATION MINERALS AROUND THE OMA-HARUKU HOT SPRINGS, CENTRAL OF MOLUCCAS

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Abstract

Petrographic analysis to rock samples located at Oma-Haruku hot springs was dominated by mudstone. Another alteration mineral types of the rocks in this area are quartz, aragonite/calcite and feldspar minerals. Petrographic analysis was supported by the XRD method. The method indicated that the alteration minerals content was generally dominated by the presence of aragonite/calcite with particle size of 0.05 - 2 mm, the abundance of 55% and the spread evenly. Based on such presence of aragonite/calcite, one can interpret that the origin rock was carbonate. Alteration minerals which were generally dominated by mudstone indicate that the type of hot spring area in Oma-Haruku is a type of high-temperature reservoir, namely > 175 °C. Therefore, the area is potentially as geothermal field in Central of Moluccas.

Keywords: XRD, petrography, carbonate, alteration minerals

ARTICLES

I. Introduction

Fault structure of Oma-Haruku is a normal fault trending Southwestern - Northeast led to the emergence of manifestations hot springs with a surface temperature of the hot water is 58.8 °C. Manifestation of hot springs in this area with regard to the presence of fractures in volcanic tuff unit is Middle Pliocene with composition of andesite lava. The exit of the hot springs of volcanic tuff fracture causes the volcanic tuff experienced changes both at the surface and at the fragment.

Physical circumstances around the Oma-Haruku hot springs brown materials are yellowish and there are also white on the surface with an indication of the surrounding alteration rocks. Depth research on the characteristics of mineral alteration by rock samples taken from the study in Oma-Haruku area hot springs performed using petrographic method.

Petrographic method was used to describe the texture of rocks to know the types of origin rock and alteration processes that occurs in rocks. Petrographic method was supported by XRD method with bulk analysis (analysis of powder and clay analysis). The XRD analysis results were a pattern that could explain the presence of alteration mineral deposits in the study area [1].

In addition, the rock samples also were analyzed using petrographic, so it can be spread and characterized the alteration of rocks on the surface of the hot springs Oma-Haruku. By mapping the alteration of rocks, it can be seen that the characteristics of geothermal fluid in the reservoir, and what happens when the fluid flow to the surface were observed.

The previous study to interpret the alteration minerals around the hot springs as mentioned in Ref. [2] that the petrographic analysis to rock samples located at Waiyari geothermal was dominated by feldspathic greywacke. On the other hand, the alteration mineral types of the rocks in this area are quartz, opaque, lithic,

and feldspar minerals. The interpretation of alteration minerals show that the mineral types of the origin rock is sandstone tuff. Petrographic analysis is supported by the XRD method that indicated that the alteration minerals present are generally dominated by the presence of clays such as illite-chlorite with particle size (< 0.03 mm), the abundance of 55 % and the spread evenly [2].

To determine the pattern and characteristics of alteration of rocks, field description and sampling was conducted. Further alteration mineralogy rock constituent using petrographic analysis, the analysis of thin section which is supported by the analysis of X-ray diffraction (XRD).

Besides XRD, Specktroscopic FTIR (*fourier transform infrared*) is one of the good analytical technique in the process of identifying the molecular structure of a compound [3]. **Figure 1** shows that there are OH groups with wave numbers ranging from 3600 to 3800 cm can have alcohol/fenol absorption. Beside that the area with the highest absorption than the sample is at the value with wave number 1690 cm^{-1} can have C=O functional group. For absorption areas with wavelengths in this range have aragonite minerals with compounds are aldehydes with vibration stretching [4].

Figure 1. Graph of the absorbance spectrum of compound sample.

Their hot tubs in the wild are one indication of a geothermal resource below the surface. This hot water pool is formed by the flow of hot water from beneath the surface through fractures of the rock. The water source can be from the ground or from the water coming from the reservoir. When the water comes from the geothermal reservoir, the water is almost always neutral.

Ellis and Mahon in 1977 said that the element chloride insoluble in steam at temperatures below 300°C . If the hot water sample analysis results obtained high chloride levels, it can be concluded type of geothermal reservoir is the kind of dominance hot water (water heated reservoir) [5].

Sulaiman, et. al. in 2007 stated that one of the geothermal prospects was the hot springs area of Akesahu with a pH between (7.4 to 7.9) which was largely of water with chloride type such as hot springs with Akesahu temperatures are relatively high, especially in Akesahu, Tomadou and Tanjungputus between (43.9 to 45.1) $^{\circ}\text{C}$ and in the hot springs found their hot water deposits or sinter whitish, brown iron oxide. This indicates that the hot water system that appeared in Akesahu geothermal area lies in upflow zone and is a type of domination reservoir of hot water (water heated reservoir) [6].

In some manifestations of hot water in the study area of alteration of rocks are formed on the surface around the hot springs. Alteration of these rocks can indicate the characteristics of the geothermal water that never interacts with surrounding rocks. By combining active manifestation, namely hot water and other outputs, and the manifestation of the remainder, ie alteration of rocks, the history and evolution of a geothermal system can be known.

Mineral such as smectite clays, quartz, feldspar, chlorite, and illite can be use an indicator of the reservoir temperature. Smectice, has a temperature below (140 - 150) $^{\circ}\text{C}$. Based on result of research from several authors in the different fields obtained of temperature variation for these minerals. For example trioctahedral smectite (saponite) does not appear when the temperature reaches (85 - 95) $^{\circ}\text{C}$, then chlorite-smectite (corrensite)

begin to form. Alteration minerals depends on several factors, but the main one is the temperature, pressure, type of origin rock, composition fluid (especially pH) and duration of response. Alteration minerals produced in the surface zona typically is kaolin, alunite, sulfur, silica, residue and gypsum [7].

Evidence of geothermal activity is show by manifestations on the surface, indicating that hydrothermal fluid originating from the reservoir has come out through fractures or units of permeable rocks. Some manifestations are important to know because they can be used as indicators in determining the temperature of geothermal reservoirs, including: hot springs and silica sinter. Silica sinter derived from hydrothermal fluid enough to get a structure containing alkaline silica, precipitated when saturated fluid, amorphous silica cooled from 100°C to 50°C. These deposits can be used as a good indicator for the presence of reservoir temperature > 175°C [8].

The appearance of silica sinter deposits on the surface is supported by water data which is the result of hot water activity where the value of silica sinter is relatively high. This usually indicates a high reservoir temperature. The rocks around these hot springs are converted into white alteration rocks and form brownish yellow deposits on the surface. In addition, hot water from the reservoir will reach the surface quickly and generally is a region with good permeability [9].

In addition, Hochstein & Browne (2000) suggest that geothermal system activity is generally related to the formation of hydrothermal alteration minerals. Alteration minerals can be used as an indicator to find out an area that has geothermal potential. Hydrothermal alteration is a feature of texture changes, mineralogy and the chemical composition of a rock caused by hydrothermal fluid activity [10].

II. EXPERIMENTAL METHOD

The primary data in the study area, among others: the measurement of water temperature on the surface, hot water colors and color of alteration rock, and rock samples and sampling rocks at each measurement station.

Analysis of rock samples were calculated using the bulk XRD analysis (analysis of powder and clay analysis or analysis of clay). The results of the analysis form the XRD patterns will be processed so that the researchers could explain the presence of mineral deposits in the study area. Additionally, rock samples were also analyzed using petrographic methods. The results of the analysis will then be processed by the researchers to determine the value of the speed of mechanical waves propagating in the rock to determine the spread and characteristics of alteration of rocks around the hot springs and reservoirs of geothermal resources in the study area.

III. RESULTS AND DISCUSSION

Hot tubs Oma-Haruku located in the village of Haruku Island, Central Maluku regency. Geographically, the hot springs are located at coordinates between 3°34'11''S and 128°29'16''E with a height of 50 m above sea level. The measurement station has the average temperature is 58,8°C and the ambient temperature is 43,1°C. Hot water Oma-Haruku accommodated in a pool of hot water dimension 2 x 3 m² with a depth of 0.5 m that flow into the rivers. Characteristics of the hot water is crystal clear, odorless sulfur, tasteless, and found a little precipitate iron oxide yellowish brown color on the surface. In addition, the hot springs Oma-Haruku found the hot water sediment or sinter whitish, brown iron oxide and the surrounding rocks already alteration. This usually indicates a high temperature reservoir.

The occurrence of boiling in the reservoir forms a fluid vapor gas temperature and relatively high pressure which exit through the cracks/fractures possibility of contamination of ground water. Pressure exerted by the fluid (hot water + steam) is greater than the outside air pressure and hydrothermal fluids below the surface of contaminated groundwater. The subsequent boiling in which fluid density decreases that made a break through to the surface (up flow) in the form of hot springs in several places in the Hot Springs area in Oma-Haruku.

Figure 2. The incision rock samples in the Oma-Haruku hot springs area.

Characteristics of mineral alteration of rock samples taken from the study Oma-Haruku area hot springs performed using petrographic methods. Petrographic analysis results in **Figure 2** show that the rock samples is dominated by mudstone, clastic texture showing incisions, closed containers, sorting good, from 0.05 to 2 mm grain size, grain shape sub-angular-rounded, composed of fragments and matrix, the abundance of 55 % in the rocks. Fragments in the form of quartz mineral, mineral aragonite/calcite and feldspar while the matrix in the form of clay minerals. Based on the presence of aragonite/calcite it can be interpreted that the origin rock is actually carbonate.

IV. CONCLUSION

Hot water in Oma-Haruku thought to have come directly from a geothermal reservoir below the surface of the water with a neutral pH. This shows the hot water in the village of Oma-Haruku island comes from the geothermal system dominance of water (water heated reservoir) by the flow of water to the upper reservoir (up flow), which is also supported by precipitated silica sinter whitish on the surface of the hot water.

Alteration mineral types of the rocks in this area are quartz, aragonite/calcite and feldspar minerals. Petrographic analysis is supported by the XRD method

that indicated that the alteration minerals present are generally dominated by the presence of aragonite/calcite with particle size of 0,05-2 mm, the abundance of 55% and the spread evenly. Based on the presence of aragonite/calcite it can interpret that the origin rock is carbonate. Thus the implication of this research with the presence of alteration minerals dominated by mudstone suggests that the type of hot spring area in Oma-Haruku is a type of reservoir high-temperature, namely $>175^{\circ}\text{C}$, thereby potentially as geothermal field in Central of Moluccas.

Aragonite/calcite are oxide minerals formed by mixing certain elements with hydroxide groups (OH) that is analysis by Specktroscopic FTIR (*fourier transform infrared*). OH is at a wave number between $3600\text{--}3800\text{ cm}^{-1}$ which has alcohol/fenol. Beside aragonite/calcite which is a alteration minerals from carbonat clay (mudstone) has a C=O fuction group, and is in a value with a wave number 1690 cm^{-1} .

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