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Application of Electrical Resistivity Method at Jaboi Hot Spring, Sabang

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ABSTRACT--*Jaboi geothermal field is a field with a potential of 50 Mwe and will be developed power plant of 2x5 MWe. The purpose of this research is to get a more comprehensive subsurface model with 2D electrical resistivity method around Jaboi hot spring. The configuration used in this study is Wenner-Sclumberger which can describe subsurface models both horizontally and vertically. This method models the subsurface conditions well based on the resistivity value of rocks divided into 3 layers. Then from line JB1, it can be interpreted as a fluid path as evidenced by the presence of manifestations on the surface. But it is not clear that a fluid path is also exist at line JB2. Based on the results of rock interpretation at the study site, it is found that what dominates is tuff mixed with pumice flakes or sandstone and clay tuff mixed with agglomerates. Aquifer layer at the study site can be found starting at a depth of 50 m with a resistivity value of 2-10 Ωm.*

Keywords—*electrical, resistivity, jaboi hot spring, sabang*

I. INTRODUCTION

Indonesia has high potential for geothermal energy which is spread in 331 locations consisting of resources of 11,073 MW and reserves of 17,506 MW [1]. Aceh is one of the regions that has the largest geothermal potential in Indonesia of 1310 MW spread over 17 locations [2]. From these locations, Jaboi is one area that has geothermal potential that can be used as a geothermal power plant. Jaboi is a geothermal field with an estimated potential of 50 Mwe with an initial development plan of 2x5 MWe [1]. Its position is on the volcanic path that allows the formation of a geothermal system. Also found are several surface manifestations of hot springs found on Weh Island (Fig. 1). These manifestations are usually associated with local faults associated with permeable zones which can be identified by gravity [3] and electrical resistivity methods [4].

Research in Jaboi has been carried out before to get an electrical resistivity response to subsurface conditions using the VES method around the Jaboi volcano and Ceunohot fault [5]. However, this research has not been able to describe the surface condition properly because it is only approached by the 1D model. So to get a better model, through this study the subsurface layer is modeled using the 2D electrical resistivity method. This method can investigate the variation of resistivity towards lateral and vertical. Therefore it can be used to determine zones that contain groundwater, faults, cavities and rock types that exist beneath the surface of an area

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II. GEOLOGICAL SETTING

The geological structure formed on Weh Island has the same pattern as the Sumatran Fault geological structure. The fault zone on Weh Island shows continuity or alignment with the Lamteuba fault (Seulawah Agam volcano) which intersects the Krueng Raya bay on mainland Aceh. Some fault zones formed on Weh Island are generally NW-SE indicated in the Balohan bay continuously to the Sabang bay. The two main faults, the Ujung Seuke and Balohan, form a graben characterized by steep cliffs east of the Balohan bay. Lake Aneuk Laot in the south of the city of Sabang is predicted to occur due to subsidence and not because of the volcanic eruption center. There is the Paya Seunara Fault to the west of the graben structure and to the south there is the Jaboi fault with the north-south direction.

Weh Island is a type of volcano C which is unknown eruption center but shows the characteristics of the fumarole field in its past activity [6]. Dirasutisna & Hasan [7] describe the lithology of Weh Island formed from Tertiary and Quaternary rocks which is divided into 4 main rock groups; Tertiary (Miocene) sedimentary rock group which is Weh Island rocks, old volcanic rock group from Weh Island which is Quaternary-Tertiary age made of lava and pyroclastic flows, Quaternary young volcanic rock groups are made of a series of young volcanic cones that form volcanic lines from northwest-southeast and north-south and a group of limestone reefs. Weh Island has several main faults (**Fig. 1**), mostly consisting of normal faults, which are the geological structures responsible for the geothermal system. There are also secondary faults formed from tectonic processes in this area such as Leumoo Matee fault (LM), Ceunohot (CT), and Jaboi fault (JB).

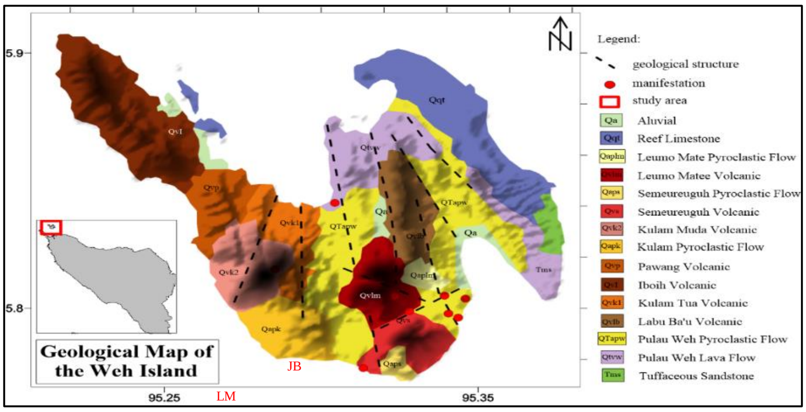

Figure 1: Geological map of the Weh Island (modified from [7])

III. METHOD

Electrical resistivity method is a geophysical method used to determine the physical character of subsurface rocks based on rock resistivity. The rock resistivity value reflects the physical condition of the subsurface rocks. In this method, the resistivity obtained is not actual resistivity but apparent resistivity (ρ_a), apparent resistivity is formulated by:

$$\rho_a = K \frac{\Delta V}{I} \quad (1)$$

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Where K is the geometry factor, ΔV is the potential difference and I is current. In fact, the earth is a layered medium with each layer having a different resistivity value.

The rules for electrode placement in the geoelectrical method are called electrode configurations. The configuration used causes the geometry factor of each configuration to be different. The geometry factor is the magnitude of the correction of the configuration of both the potential electrode and the current electrode. In this study the configuration used is the Wenner-Schlumberger configuration (**Fig. 2**).

The Wenner-Schlumberger configuration is a combination of the Wenner and Schlumberger configuration [8]. In this configuration the distance between the electrodes P1 and P2 is a and the distance between C1P1 = P2C2 is na. The distance between the electrodes is constant and has superiority horizontal coverage, good depth penetration. The results of the combination of Wenner and Schlumberger cause the k value of the geometric factors also change, namely:

$$k = \pi n(n+1)a \qquad (2)$$

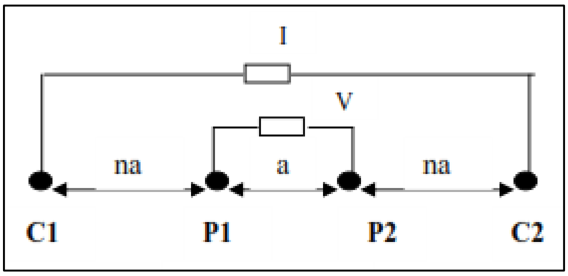

Figure 2: Four points electrodes arrangement with current and potential [9].

This research was carried out on the Jaboi coast, Sabang. The measurement line consists of two line namely JB1 and JB2 where JB1 path is close to hot spring manifestation (**Fig. 3**). Data was collected on 2 line with a length of 395 m and spacing between electrodes 6 m. As for the height and position data taken at each electrode using GPS. Data processing in this research used RES2DINV based on least squares optimization method to identify subsurface geological condition. This programme provides inverse pseudosections of resistivity, windows will be determined and shown that 2D subsurface resistivity model from data surveys [10].

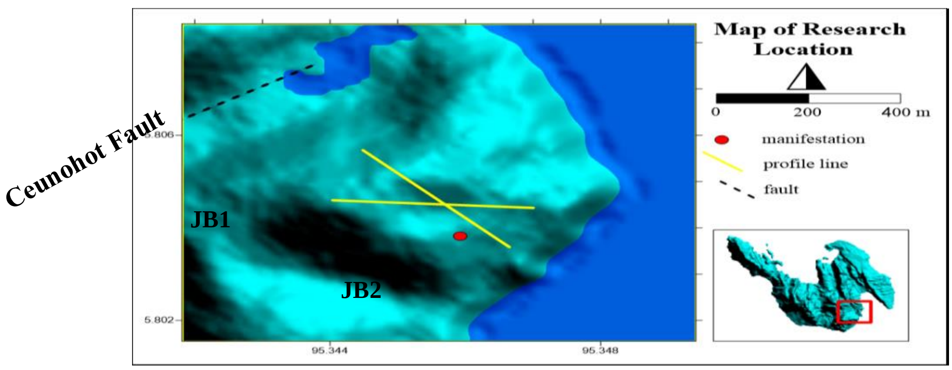

Figure 3: Map of research location showing manifestation (red dot), two profile line (JB1 and JB2) and Ceunohot Fault

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IV. RESULTS AND DISCUSSION

The value of rock resistivity can be influenced by several factors, including porosity, permeability, and the presence of fluid types. Porosity and permeability in the rock provide space to be filled by the fluid causing low rock resistivity. The resistivity model for line JB1 is interpreted as having a fluid path to the surface supported by manifestations on the surface area (**Fig. 4**).

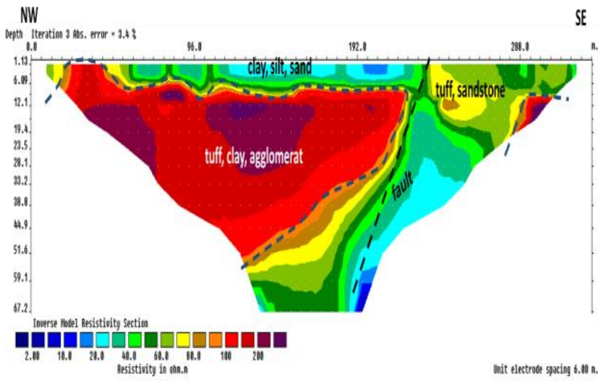

Figure 4: Cross section of 2D resistivity line JB 1

The resistivity model then correlated with drilling data [11]. The top layer for line JB1 interpreted as a clay, silt and sand from fine to roughness mixed with pumice stone to a depth of 12 m with a resistivity values of 10-50 Ωm. The geological conditions of the area as a volcanic area allows to obtain a mixture of pumice stone at the rocks layer. However, due to the large measurement spacing of 6 m, of course the pumice stones which are few in the mixture of other rocks are not found.

A layer at distance of 0-230 m with a depth of 12-51 m with a resistivity values of 100-300 Ωm is a dominant of clay mixed with agglomerates which causes this layer to be watertight. At this layer it is also possible to find an abundant amount of pumice stone and andesite chunks on it. At a distance of 230- 330 m, a resistivity value of 50-100 Ωm is obtained. This shows that the rock consists of a dominant tuff with a piece of pumice above and a solid sandstone mixed with tuff and pumice below.

As for the line JB1, an aquifer layer is also obtained where the value of the resistivity is low (conductive) <10 Ωm which is found at a depth of 59 m to a distance of 190 m. This aquifer layer is a sandstone with high porosity.

In the line JB2 at a distance of 120-198 m and a depth of 0-12 m, it is found a layer of clay, silt and sand from fine roughness mixed with pumice. The dominant layer of clay mixed with agglomerates was interpreted at a distance of 108-230 m and a depth of 12-51 m. It is also interpreted rocks with a dominant composition of tuff mixed with pumice flakes on the top and sandstone mixed with tuffs and pumice flakes on the deeper parts. At a depth of 51-55 it is a dense silt sand and also obtained a layer of sand that pivots at a depth of 55 m to a distance of 236 m continuously towards the east.

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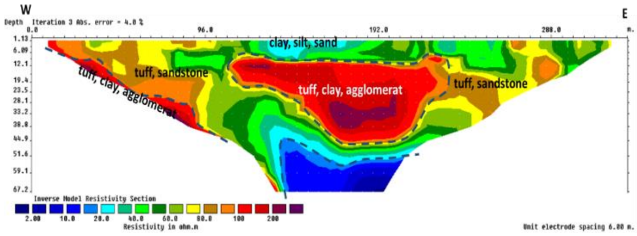

Figure 5: Cross section of 2D resistivity line JB 2

V. CONCLUSION

This research provides significant evidence that shows a fluid path of Jaboi hot spring from JB1. But it is not clear that a fluid path is also exist at line JB2. Resistivity values in the research area ranging from 10 - 50 Ωm are clay, silt and sand layers. The resistivity value of 50-100 Ωm is interpreted as a layer of tuff mixed with pumice flakes and sandstone. As well as for resistivity between 100-300 Ωm, it is interpreted as mixture of clay tuff and agglomerates. Based on the results of rock interpretation at the study site, it is found that what dominates is tuff mixed with pumice flakes or sandstone and clay tuff mixed with agglomerates. Aquifer layer at the study site can be found starting at a depth of 50 m with a resistivity value of 2-10 Ωm.

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