Analysis Of The Geothermal Potential Based Fault Zone In Burni Telong Bener Meriah, Aceh, Indonesia

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Abstract. Mount of Burni Telong located in Bener Meriah, Aceh, Indonesia is one of the mountains that have the potential for development of renewable energy from geothermal sources, but is still untapped. The evidence suggests that, to date Aceh still depends on power supplies from North Sumatra. This dependence often affects alternate electricity blackouts all over the province so that the necessary rationale for their source of power generation in Aceh. The purpose of this study was to analyze the potential development of Burni Telong as geothermal energy power plant in Aceh, Indonesia.This study was a survey with the approach in the field of geophysics. Analysis of potential geothermal done using the gravity method to investigate the distribution of mass in the subsurface. The study found that there are two tracks, namely: A-A' and B-B track'. A-A' tracks has four layers, composed of: Riolitic Tuff (1.77g/cm^3), basaltic Tuff (2:12 gr/cm^3), Diorites (2.78 gr/cm3),and basalt (3:00 gr/cm^3). B-B' tracks has three layers, namely: Basaltic Tuff (2.12 gr/cm^3); Diorites (2,78 gr/cm^3), and basalt (3.00 gr/cm^3). In both of these trajectories found two faults, namely: normal and Horst. It can be concluded that the difference in density contrast and hot springs that are parallel to the fault indicates a fault in Burni-Telong, so Burni Telong has the potential Geothermal and very likely to be developed as a source of electricity generation from geothermal energy in Aceh, Indonesia.

Keywords: volcanic, geothermal, renewable energy, electric power, fault, geophysics

INTRODUCTION

Indonesian government's policy for the utilization of renewable energy are being pursued at this time. One of the renewable energy is geothermal energy. Almost all countries in the world began to develop renewable energy from geothermal energy and even some countries already use geothermal energy long ago. An estimated 40%, or approximately 29.038 MW of geothermal potential of the world are in Indonesia.[1] There are several areas of geothermal prospects in Indonesia, namely Sumatra, Java, Nusa Tenggara, Maluku and Sulawesi, which form the ring of fire. A geothermal system in the island of Sumatra related to the activities of volcanic andesitic-riolitis caused by magma source that is more acidic and more viscous, whereas in Java, Nusa Tenggara and Sulawesi are generally associated with volcanic activity are andesitic-basaltic with magma source more liquid.[2]

In Aceh there are some areas that have geothermal potential include: Iboh, Lho Men laot, Jaboi (Kota Sabang), Ie museum, seulawah Agam (Aceh Besar) Flow Canang, Alue Long, Tangse (Pidie), Rimba Raya, Simpang Balik (Bener hilariously), Geureudong, Silih Nara (Central Aceh), Brang Crocodile (Aceh Tamiang), Kafi, Mount Twins and Dolok Perkirapan (Gayo Lues). The total potential reach 1,115 MWe.[3]

Currently, geothermal field has never been done Burni Telong exploration and even a preliminary study as a first step to assess the geothermal potential. Whereas the supply of the power source dependency Aceh region of North Sumatra is the main reason necessary to develop electrical energy from geothermal resources. The beginning stage to determine the geothermal potential can be done using the method: geology, geochemistry and geophysics. The explanation of geological and hydrogeological conditions that is in combination with the interpretation of the geothermal reservoir based on the electric resistance survey as well as other geothermal methods (e.g., isothermal mapping, geothermometers, geophysics: gravity and magnetic).[4]

This study using one of the methods of geophysics, namely: gravity. This study aims to determine the subsurface structure by lateral density differences of the physical properties of rocks and analyze the potential of geothermal Mount Burni Telong based fault zone. The results of this study, the data on density, types of rocks, layers of rock and fault zone. Data from this study will demonstrate the potential Geothermal potential is based on the fault zone at Mount Burni Telong, Aceh Indonesia. This study is a follow-up that has been done in 2015.

Previous research by Nugraha et al (2016: 204) found that there is potential for geothermal Mount Burni Telong Bener Meriah (based on analysis of geoelectric and geologic). It is based on the discovery of several manifestations on the surface of Mount Burni Telong such as fumaroles, alteration and kaipohan. Outcrop acquired alteration consisting of sulfur, skis mica, quartz, sandy tuff. Kaipohan obtained in Mount Burni Telong form: gas release, the roar and the absence of anomalous heat.[5]

METHODS

A. Research sites

This research was conducted at Mount Burni Telong, Bener Meriah, Aceh Indonesia. Data is collected on Mount Burni Telong at an altitude ranging between 1100 to 1400 meters above sea level. Here is a collection of field data locations in Mount Burni Telong.

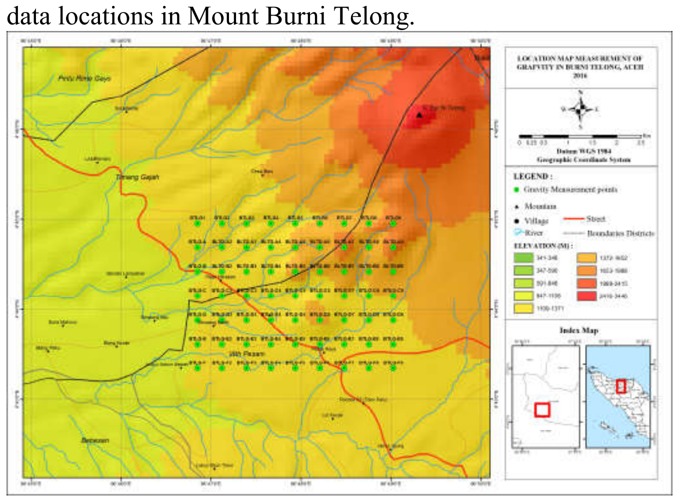

Figure 1. Location map data retrieval gravity in Mount Mount Burni Telong, Aceh-Indonesia.

B. Research methods

The method used in this study, include: methods of gravity at the location as shown in Figure 1 and data processing. Measurements of gravity in the form of a randomized grids by using the principle of loops. Qualitative data processing is done using Surfer 11. The data analysis consists of two phases: analysis and modeling of Bouguer anomaly Bouguer anomaly. Anomaly analysis used in this study, are: Bouguer residual anomaly on two tracks, namely cross-section A-A 'and cross section B-B'.

C. The tools used in this study

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The tools used in this study, are: Gravimeter Scintrex CG-5 (Figure 2.A), thermometer (Figure 2B), Global Positioning System (GPS) (figure 2.c), software and Grav2DC surfer.

Figure 2.a Gravimeter Scintrex CG-5

Figure 2.b thermometer

Figure 2.c Global Positioning System (GPS)

RESULT AND DISCUSSION

Based on the results of data processing and modeling using Surfer 11 Bouguer residual anomaly response value on line A-A 'and B-B track' obtained coordinates of the point cross-section as shown in Table 1.

Table 1. Points coordinate trajectory residual Bouguer anomaly

No.	Cross Section	lenght cross-section (m)	North latitude	East longitude
1.	A - A’	2.584	4.749425 - 4.735609	96.803546 - 96.822579
2.	B – B’	3.334	4.748139 - 4.723052	96.794503 - 96.808522

Table 1 shows, the orientation of the cross section A-A 'and cross section B-B' has a northwest to southeast direction, lane cross-section passing through the manifestation of hot springs and fumaroles as shown in Figure 3.

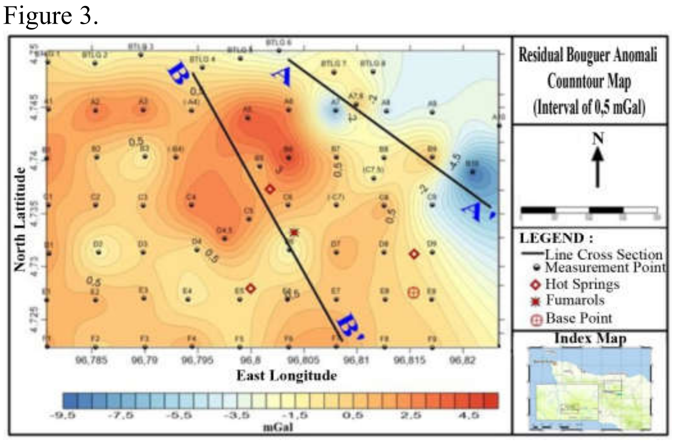

Figure 3. Cross-section of Mount Burni Telong Aceh-Indonesia.

Figure 3 shows the value of the cross-section obtained from the analysis of residual Bouguer anomaly continuation of 500 m. Furthermore, the results of this analysis followed by further analysis using modeling using software foward Grav2dc. This analysis resulted in a conceptual geological model and lower density surface mount Burni Telong (figure 4). The modeling is done by reference, geological maps, literature and field data.

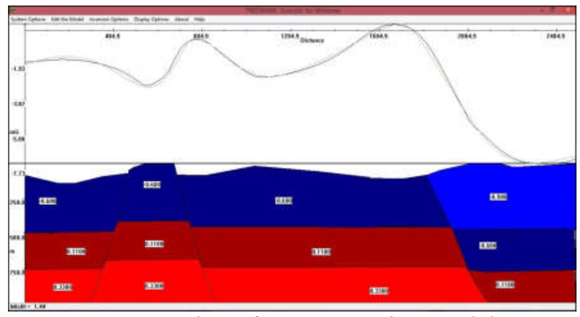

Figure 4. Cross-section of a cross-section models Grav2dc A-A 'in Mount Burni Telong.

Figure 4 shows that the dotted lines contained in cross-section A-A 'shows the value of anomalous response Burni Telong mountain, while the continuous line is an anomaly of the modeling results in Mount Burni Telong. The depth of the model reaches 1000 m from the surface, while the length of the cross section reaches 2584 m. The color difference in cross section showing layers that have different density values, the blue light has a density value of -0.9 g/cm3, a dark blue color = -0.6 g/cm3, dark red=12:11 gr/cm3, red light= 12:33 gr/cm3. Misfit were obtained in cross-section A-A 'is 1:44. The error rate calculation with measurement data is calculated using the formula Root Mean Square Error (RMSE) as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(d_{obs,i} - d_{prediksi,i})^2}{n}}$$

The calculations show the error rate is 0:14.

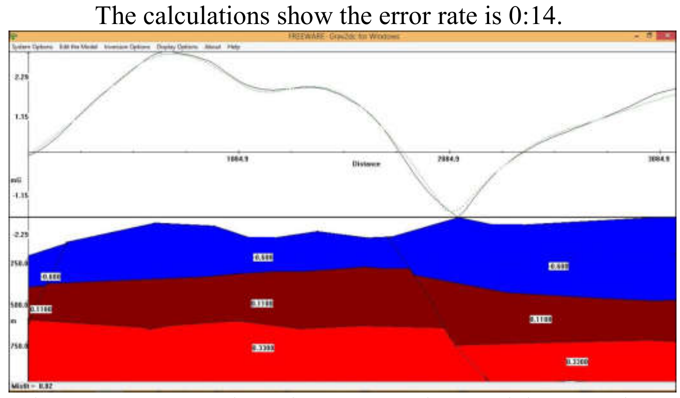

Figure 5. Cross-section of a cross-section models Grav2dc B-B 'in Mount Burni Telong.

Gambar 5 memperlihatkan penampang B-B’ mempunyai kedalaman 1000 m, dan panjang penampangnya adalah 3356,125 m. Warna mempunyai nilai densitas -0.6 gr/cm^3, = 0.11, gr/cm^3 = 0.33 gr/cm^3. Misfit yang peroleh pada penampang B-B’adalah 0.82. Adapun tingkat kesalahan berdasarkan rumus RMSE didapatkan nilai sebesar 0.08.

Hasil analisis data untuk memperkirakan kondisi bawah permukaan berupa patahan pada penampang A-A’, seperti yang ditunjukkan pada gambar 6.

Figure 5 shows that the cross-section B-B 'has a depth of 1000 m, and the length of cross-section is 3356.125 m. Color has a density value of -0.6 g/cm3, = 0:11, gr/cm3, and = 0.33 gr/cm3. Misfit is obtained on the cross section B-B'adalah 0.82. The error rate is based on the formula RMSE values obtained at 0:08. The results of data analysis to estimate subsurface conditions such as fracture on the cross-section A-A ', as shown in Figure 6.

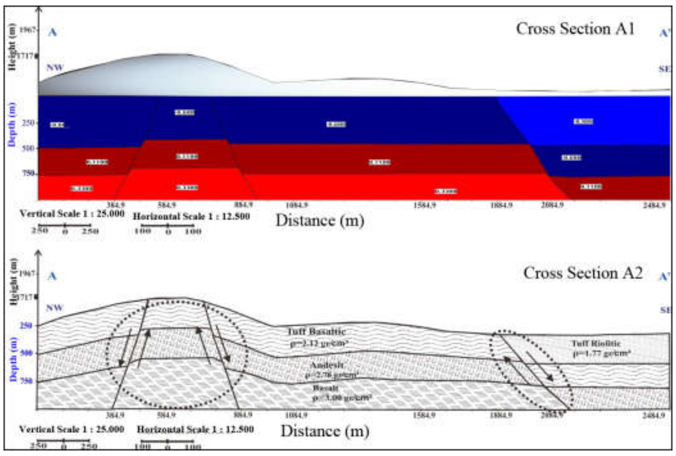

Figure 6. Description of the fault zone in the cross-section A-A ': the combined cross section of subsurface cross section Grav2dc and Topography (Figure A1) and Conceptual A-A' (Figure A2).

Based on data analysis using modeling Bouguer anomaly in cross section AA showed that the cross-section A-A 'has four layers alleged, are: Tuff Riolitic with the value of the density of 1.77 g / cm3 (Wohletz et al, 1992), Tuff basaltic: the value of density 2:12 gr / cm3, Andesite: density value of 2.78 and a density value of Basalt with 3:00 gr / cm3 (Figure 6). The results showed in cross-section A-A 'was found two fractures / faults, the normal fault and Horst. Estimates of the fault is based on the results of the analysis of differences in density values.

Fault is a fracture in the rock layers form the Earth that causes the rock block moves relative to the other blocks. The movement can be relatively lower, the relative rise, or move horizontally relative to the other blocks. Sudden movement of a fault or faults can lead to earthquakes. Fault (fault) is an area of fracture or zone of fractures in rocks which have undergone a shift.[7]

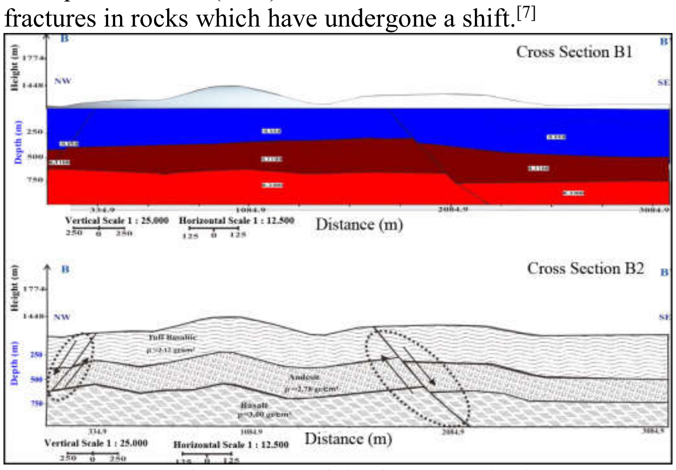

Figure 7. The description of the fault zone in the cross-section B-B ': the combined cross section of subsurface cross section Grav2dc and Topography (Figure B1) and Conceptual B-B' (Figure B2).

Figure 7 shows that the cross-section B-B 'starts from northwest to southeast. This cross-section seen cutting the two manifestations of the hot springs and fumaroles one manifestation. In its section also looks a fracture or sections are slightly down. The location is adjacent to flow down rivers in Burni Telong. The cross-section B-B 'has three layers, namely: the top layer is estimated basaltic tuff with 2:12 density values gr / cm3, the second layer from the top in the form of andesite rocks with a density value of 2. 78 g / cm3 and the third layer is a rock with a density Basalt 3:00 gr / cm3, this layer is estimated to come from the volcanic eruption.

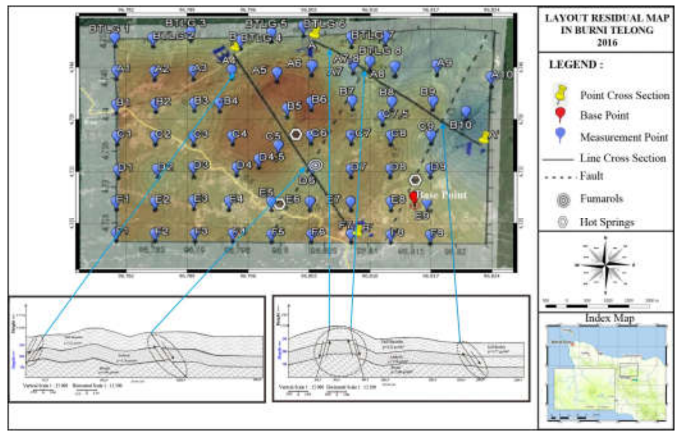

Figure 8. Results Interpretation Residual Bouguer contours and imagery of Google Earth.

Figure 8 shows the approximate location of faults that exist in a cross-sectional A-A 'and B-B' in Burni Telong. The dashed line indicates the approximate location of the black fault, the red color indicates the location of the fracture, continuous black line is a cross-section that is modeled. The result showed there were faults in the northeast-southwest. The results of the analysis researchers estimate the fracture occurred as a result of the volcanic activity, whether it be the pressure of the magma below the surface, or other causes such a tectonic earthquake (Sumatran Fault).

Classifying geothermal systems with regard to the depth of heat exploitation makes a distinction between shallow and deep geothermal energy. For shallow geothermal energy, heat is extracted from depth down to about 100 meters using ground source heat pumps and used for direct heating or cooling and to store excess heat in the summer and use it in winter. In the case of deep geothermal energy, heat is extracted from depths of about 1,500 meters and deeper and e.g. used for district heating systems.[8,9] The world geothermal power is an indispensable component of renewable energy resources. Efficient utilization of this component requires effective geological, geochemical, and geophysical approaches to resource characterization to optimize the reservoir performance.[10] Geophysical data in this research using gravity method to analysis of faults in Burni Telong, Aceh, Indonesia.

In geothermal systems, faults, fractures, or contacts between intrusive and surrounding rocks may become conduits for thermal water. The three geothermal fields mentioned above exhibit some geological similarities. Firstly, the geothermal fields are high temperature geothermal systems, where hydrothermal alteration is generally very intense and can mask the appearance of faults or fractures. Secondly, the fields are within low to moderate terrain, causing the hydrological flow to spread at short distances, and thus, the surface manifestation of thermal water such as springs, fumaroles, and hydrothermally altered rock are concentrated in nearby low terrain areas. Hence, the reservoir may be located close to the manifestation area.[11] Characterizing fault zones in geothermal systems plays a key role in improving reservoir performance. As faults might behave as both barriers and conductors of fluids, they basically dominate subsurface fluid flow processes.[12]

Fault is a geological structure as a factor to estimate the geothermal potential in Burni Telong. Four major components forming a geothermal system are: a heat source (heat source), the reservoir rock (permeable rock), rock cover (cap rock) and as well as fluid flow (fluid circulation). The existence of the fault zone resulting in the flow of fluid beneath the surface of the earth to the surface of the earth, it is called a manifestation.

Geothermal energy resources have long been associated with the presence of crack systems that are Presumed to provide pathways for transport of hot fluids.[13] The existence of a fault in the line A-A 'and B-B' indicate the presence of subsurface fluid flow path on the mountain Burni Telong. Fault can produce a fracture zone which

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subsequently became media movement of fluid beneath the surface, or vice versa fluid flow out from under the surface as heat and excessive pressure from below the surface.

CONCLUSION

It can be concluded that: (1) there are differences in the distribution of the value of the acceleration of gravity at Mount Burni Telong, namely; distribution of the lowest values are in the east and northeast, the distribution of the highest value to be central and western Residual Bouguer contour maps. The value of the acceleration of gravity range between -9.5 - 4.5 mGal. (2) Based on the model of the density values obtained at the following cross sections: the first layer of basaltic Tuff (2:12 gr / cm3) and Tuff Riolitic (1.77 gr / cm3), the second layer Andesite (2.78 gr / cm3) and the third layer of rock Basalt (3.00 g / cm3). While the second cross section consists of three layers, namely Tuff basaltic (2:12 gr / cm3), the second layer Andesite (2.78 gr / cm3), and the third layer is Basalt (3.00 gr / cm3).(3) In the cross-section A-A '3 ditemukaan their faults and three fault is a normal fault, while the cross-section B-B' had only two faults and both were classified as normal faulting. The existence of this fault is strengthened by the emergence of several manifestations around the mountain Burni Telong, are two manifestations of the hot springs and fumaroles one manifestation. (4) The difference in density and thermal springs that are parallel to the fault indicates a fault in Mount Burni Telong, so Mountains Burni Telong Geothermal has potential and is very likely to be developed as a source of electricity generation from geothermal energy in Aceh Indonesia, but still requires further research.

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