2D Inversion of Magnetotelluric Data from Wapsalit Geothermal Field, Indonesia

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ABSTRACT

Magnetotelluric (MT) measurements have been conducted at 30 sites around the Wapsalit geothermal field in Buru Island, Indonesia. Analysis of the two dimensional magnetotelluric data has been done to delineate the location of the geothermal prospect area. Field data in the form of time series data was processed to produce an apparent rho and phase against a frequency curve. From each curve a solution was found using the non-linear conjugate gradient method that minimizes the objective function as a method of inverse modelling. A resistivity cross section with the smallest rms error was obtained by modifying the inversion parameters and the initial mesh model, this was done for several iterations. The result of the resistivity section obtained at a low resistivity layer less than 20 Ohm-m is visible from the surface to the depth of 1000 meter under sea level. Then the middle area began at a depth of 500 meter to the depth of 1800 meter. The high resistivity predicted to be as the top reservoir at a depth of 1800 meter with resistivity values ranging from 20-200 ohm-m.

1. INTRODUCTION

The Wapsalit geothermal field is located in Buru Island, Maluku province, Indonesia (Fig.1). On Maluku, the Wapsalit area is one of the potential geothermal fields that has been identified. Manifestations of the hot springs that appears in this area are the Wapsalit hot spring with temperatures between 99.8-101.3 ^{0}C and the Metar hotspring with temperatures between 63-65 ^{0}C. Geophysical methods have been undertaken on this area in 2007, these methods include the methods of gravity, magnetism and DC Schlumberger. The resistivity values showed a shallow low resistivity distribution fill Wapsalit depression zone, spreading out to the north of the Wapsalit hot springs.

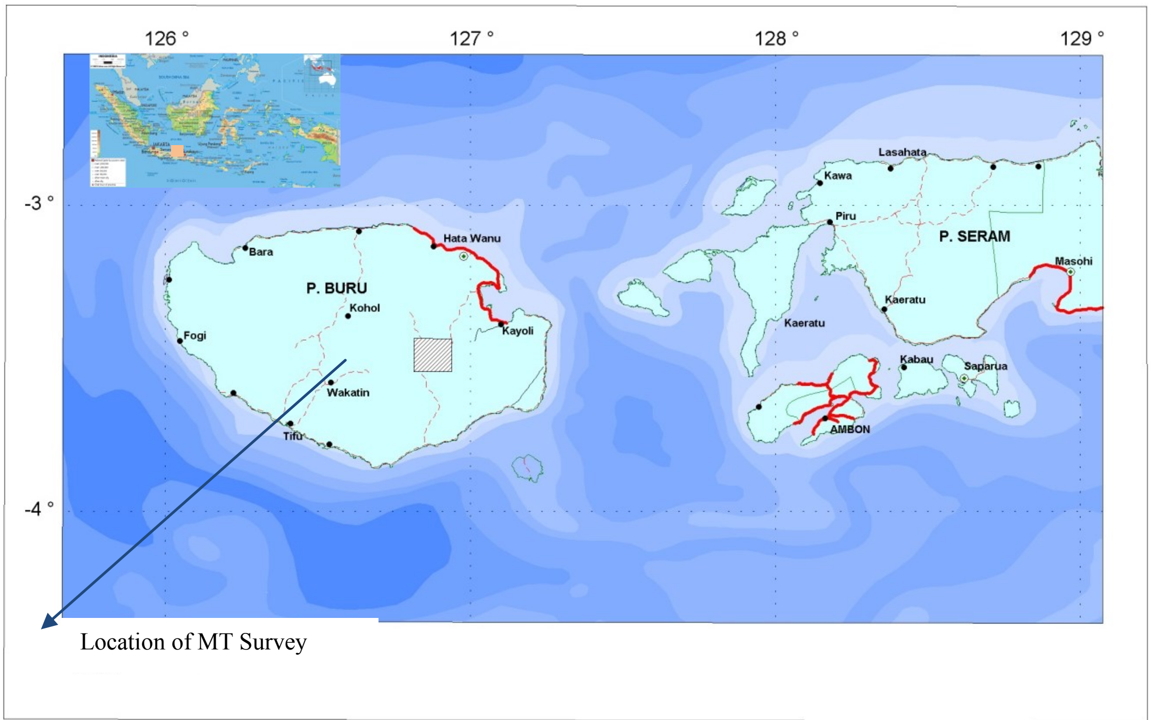

Figure 1. Location map of MT Survey

The subsurface resistivity distribution is one of the key information for the exploration of geothermal reservoirs. The magnetotelluric method is a very popular method to investigate the subsurface resistivity distribution for geothermal exploration purposes. An MT method was chosen because it has a fairly deep penetration (more than 5 km) and has a high sensitivity in detecting conductive layer between the resistive layers. This paper present the results and interpretation of MT measurements in Wapsalit geothermal field from 2D inversion.

2. GEOLOGICAL BACKGROUND

Stratigraphy of this area is divided into four types of rocks. The metamorphic rocks are the oldest rocks/metamorphic, followed by claystone, collovium and alluvial (Fig.2). Manifestations appears in the form of hot springs, hot soil, alteration, fumaroles and sinter silica.

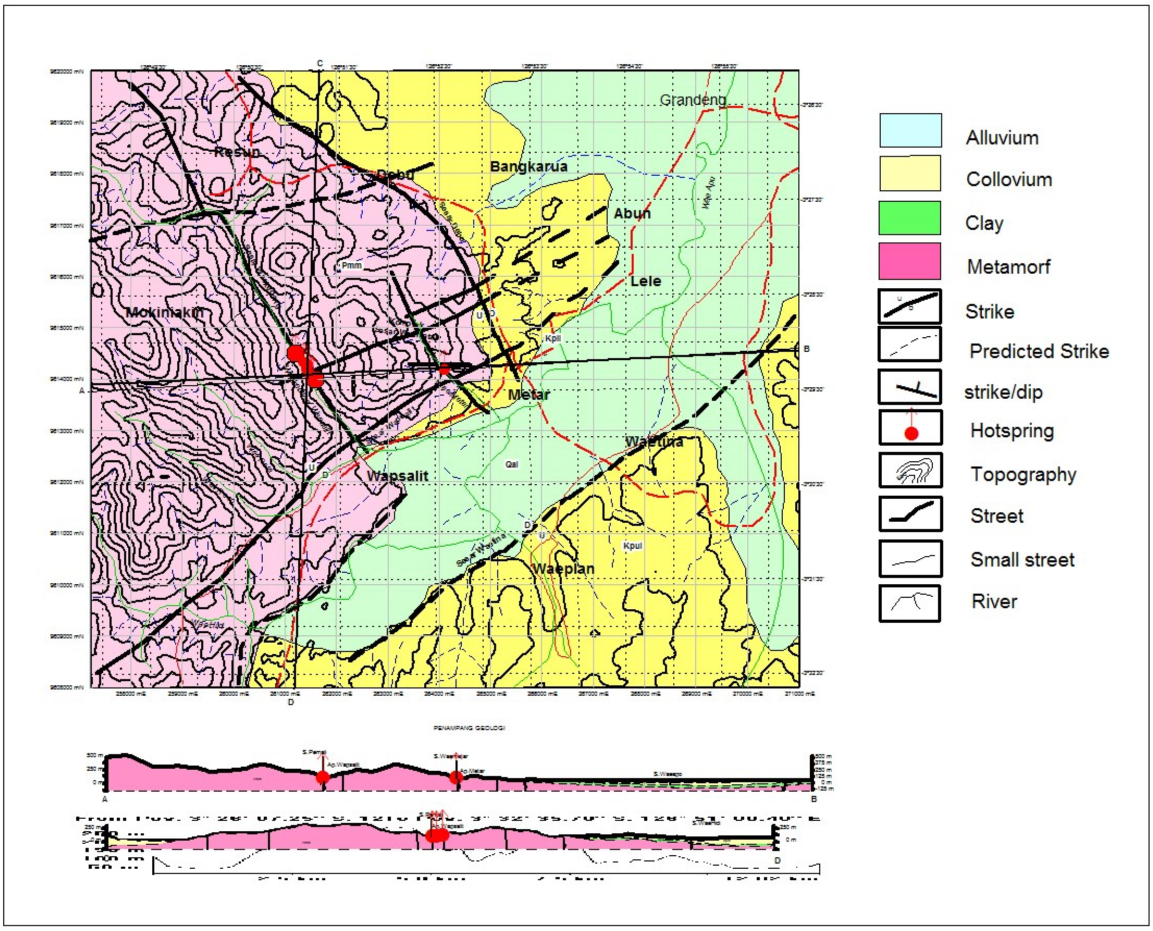

Figure 2. Geological Map of the Wapsalit Area

The structure of the Wapsalit normal faults trending southwest - northeast and Waemetar normal faults trending Northwest - Southeast is a fault that will play a major role in the appearance of manifestations of hot spring in this area. General tectonic pattern formed in this area is composed by oblique fault trending the northwest-southeast and northeast - southwest.

3. MT MEASUREMENT

MT measurement have been conducted in the Wapsalit area in October 2012 with a number of measuring points by 30 MT sites. Distribution of the MT measuring points covers Metar and Wapsalit hotspring manifestations (Fig.3) The distribution MT stations were placed between 500 to 1000 meters from each other and designed in such a way that they can cover the entire area to predict the geothermal prospects.

MT measurements were performed from noon until the next morning with an interval between 18 - 21 hours, the MT tool used was a MTU-5A from PHOENIX. Time series data were obtained from measurements of two components of the electric field (Ex and Ey) and three components of the magnetic field (Hx, Hy and Hz).

4. DATA PROCESSING

2D resistivity modeling of MT data was performed using the Non-Linear Conjugate Gradient (NLCG) algorithm which is discussed in Rodi and Mackie (2001) and Ushijima, et al (2005). This inversion using the WinGlink software, before the inversion process, the selection of the parameters in WinGlink Software as a mean in order to get the maximum rms value.

Some of them uses an error floor of 50% for the TE apparent resistivity, 10% for the TM apparent resistivity and 1.5° for the phases of both modes. the optimal value of the smoothing parameter (τ) from L-curve analysis was found to be 3 (Fig.5).

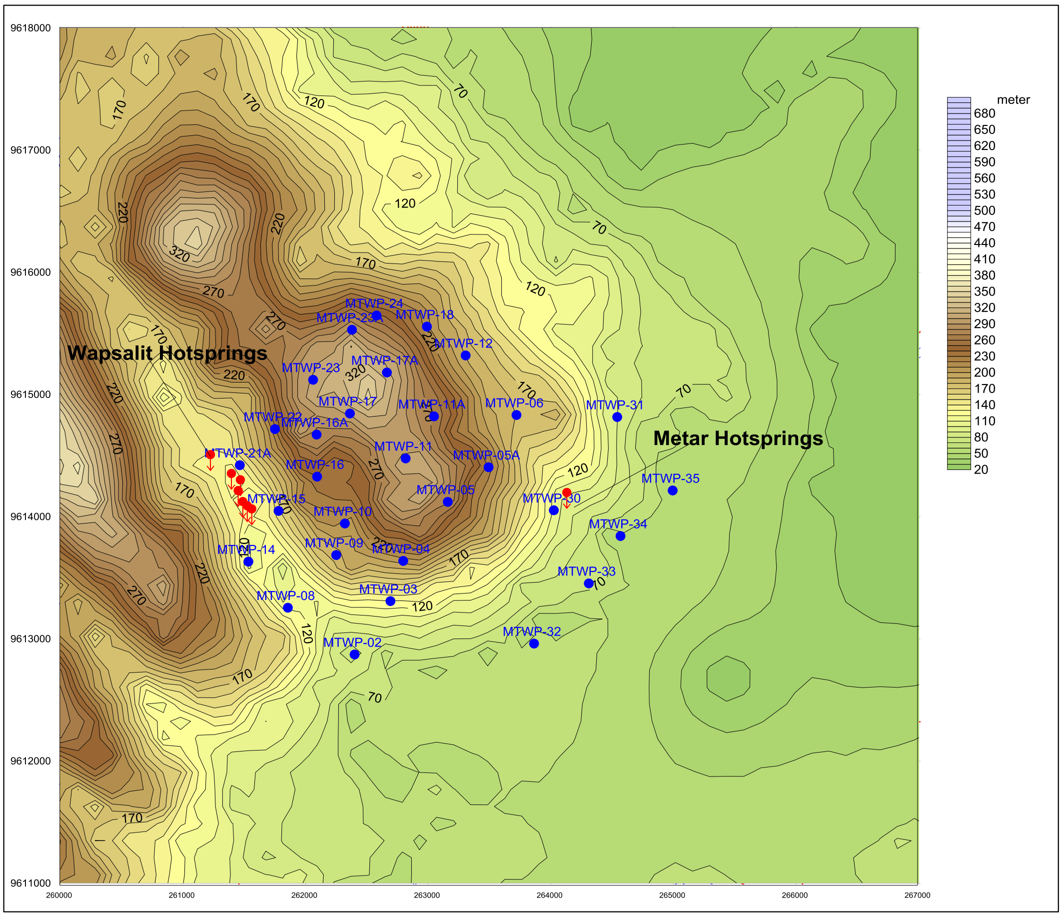

Figure 3. Magnetotelluric survey stations (blue circles) and hotsprings (red circles-triangle)

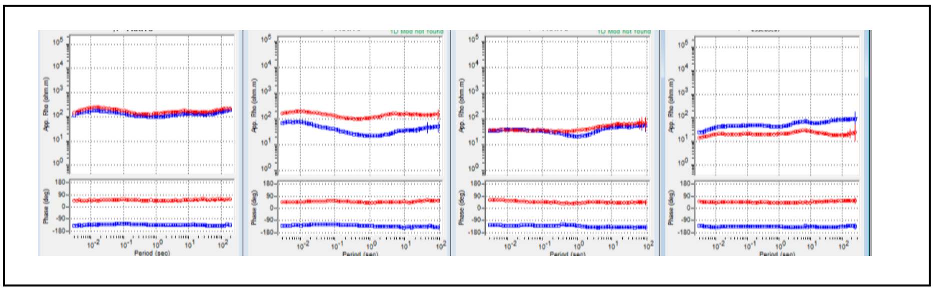

Figure 4. Some observed MT Sounding Curve

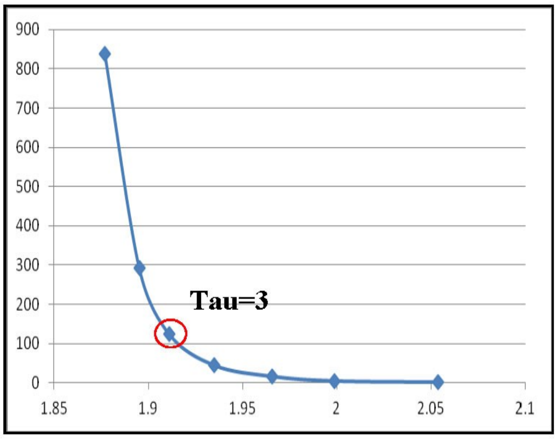

Figure 5. L-Curve RMS vs Roughness of Line 2

5. DISCUSSION

The result of the 2D inversion can be seen on Figure 6, where there is a high resistivity near the surface until about 1000 meters deep in the northeast and the low resistivity region of less than 20 Ohm-m is visible from the surface to the depth of 1000 meters under the sea level. Then, in the middle of the area the low resistivity region began at a depth of 500 meters to 1800 meters. The high resistivity at began at a depth of 1800 meter and has resistivity values ranging about 20-200 Ohm-m

Low resistivity are estimated to be a clay cap distributed in the middle area around the Wapsalit hot springs, the low resistivity distribution deeper to the northeast area.

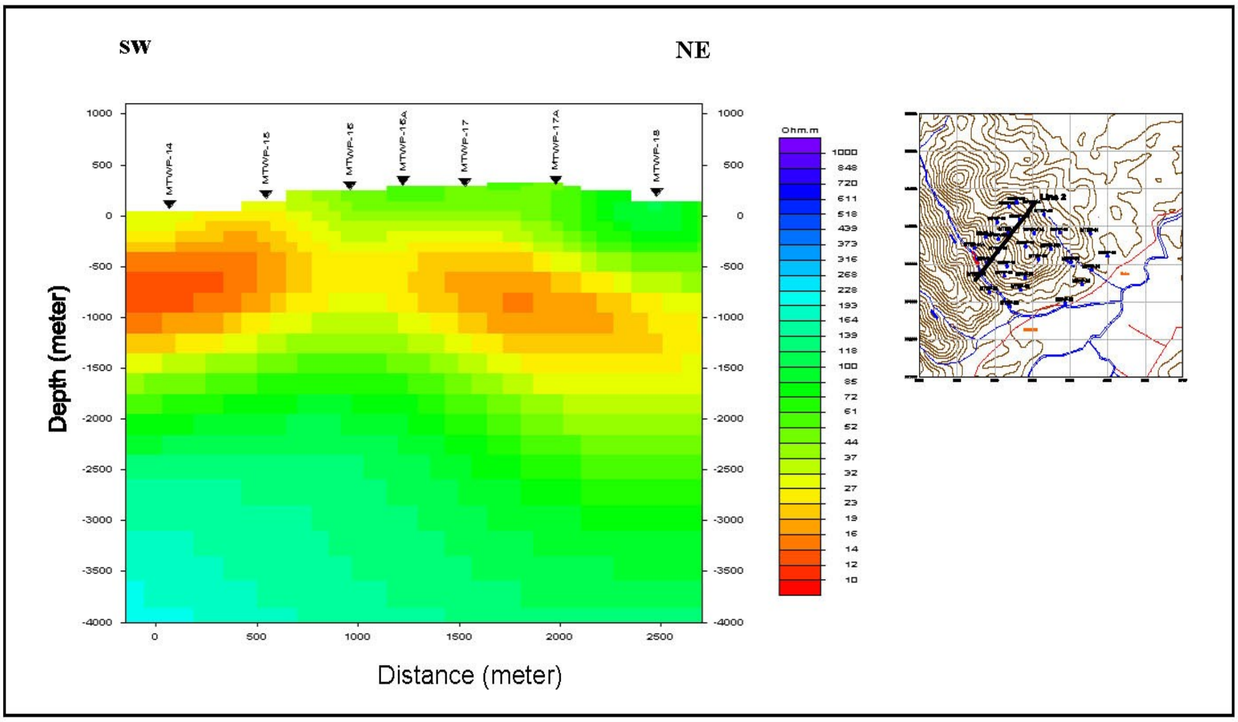

Figure 6. Resistivity models obtained by 2D resistivity inversion on line 2

6. CONCLUSION

A MT survey was performed at the Wapsalit geothermal field for the purpose of delineating a geothermal prospect area. The results from 2D resistivity modeling obtained, showed a low resistivity region around the manifestation with Wapsalit being shallower than the northeast area. The low resistivity layer is visible from the surface to the depth of 1000 meter under sea level, this low resistivity distribution still opens towards the northern part of this area.

2D inversion of MT data gave a good result to help understand the reservoir structure. The low resistivity area was estimated to be a clay cap near the surface and distributed in the middle area around the Wapsalit hot springs, with the low resistivity distribution deeper to the northeast area. Further 2D inversion and 3D modelling is necessary to better understand the geothermal system in this area.

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