Abstract. Magnetotellurics method survey has been used for investigation subsurface structures of geothermal field of Seulawah Agam, District of Aceh Besar, Aceh Province. Transfer function of Magnetotellurics data were collected using MTU Unit instrument. We have recorded 2 components of electric fields and 3 components of magnetic fields in the range of frequency from $10^{-5}$ to 1 kHz. 5 stations with spacing varied from 2 to 10 km were measured along a profile with length of 30 km. The profile crosses Seulawah Agam volcano in south-north direction. Apparent resistivity and phase data of TE mode were included for 2-D inversion modeling using the MT2DInvMatlab code. The inverted model shows well distribution of electrical conductivity associated as hydrothermal structure. At the depth of 200-800 m there is a conductive layer ($\rho < 10 \, \Omega m$) predicted as cap rock structure and at the depth of 1-4 km there is a hydrothermal reservoir indicated by resistivity values 100-1000 $\Omega m$.

Keywords: Magnetotellurics method, resistivity, 2D modelling, Seulawah Agam.

INTRODUCTION

Geothermal energy is energy stored in rocks below the Earth’s surface and the fluid contained therein. Most of geothermal systems are found along subduction zones. Indonesia is a country located at triple junction plate tectonic setting where the Eurasian, Pacific, and indo-Australian plates meet. The condition puts Indonesia as a biggest country in the world with geothermal resources (Fig. 1). One of them is found at Seulawah Agam Volcano in Aceh Besar Regency of Aceh Province. Aceh government is going to develop electricity power plant at Seulawah Agam Area in the next couple years. Therefore depth studies on geothermal prospecting are urgently needed in the area. In this paper we present a preliminary result of geophysical method of Magnetotelluric (MT) measurement on Seulawah Agam area.

FIGURE 1. Range of volcanic region in based on [2].
Electromagnetic Method. In terms of the origin of the source of electromagnetic waves are used, the MT measurement is a method of passive electromagnetic (EM) that measure the fluctuations of the electric field ($E$) and the magnetic field ($H$) in the direction of the natural orthogonal to the surface of the Earth as a means to determine structures of Earth conductivity from a depth of dozens of meters to thousands meters [3]. The MT method utilizes a variation of the current telluric in the frequency range $10^{-3}$ to $10^{4}$ Hz. Magnetotelluric equipment can detect the terrain through the primary and secondary air (ionosphere), so the field effect of primary and secondary fields can be detected, and there will be different phases and relative amplitude that can be detected at the receiver. Due to the difference of the measured components, the method will reveal the existence of important information about electrical and magnetic parameters arising in a wide range of conductive medium. Information on the electrical conductivity of the medium contained in data magnetotelluric can be obtained from the completion of Maxwell's equations.

Variation of electrical resistivity below subsurface can be calculated based on the formulations introduced by [1]. If it is assumed that electromagnetic waves penetrate the Earth homogenous isotropic, then apparent resistivity ($\rho_{xy}$) and phase ($\phi_{xy}$) can be calculated based on impedance elements ($Z$), i.e.

$$\rho_{xy} = \frac{1}{\omega \mu_0} |Z_{xy}|^2$$

and

$$\phi_{xy} = \tan^{-1}\left(\frac{\text{Im}(Z_{xy})}{\text{Re}(Z_{xy})}\right)$$

where $\omega$ is frequency and $\mu_0$ is magnetic permeability of free space. The subscript of $x$ and $y$ in the equations are indicate direction of electric and magnetic fields measurement, respectively.

**METHODS**

Magnetotelluric data were performed in four districts in the region of Aceh Besar, i.e. in Jantho (C1 and C2) point, Lembah Seulawah (C3), Seulimum (C4), and Mesjid Raya (C5). The distance between the stations vary where between C1 and C2 is 1.04 km, C2 and C3 is 11.8 km, C3 and C4 is 13.5 km, and C4 and C5 is 3.7 km. The stations are almost formed in strike line crossing the SeulawahAgam volcano in the South to North direction. The data were measured from each stations varied from 6 to 12 hours with frequencies from 320 to 1.03 Hz.
RESULTS AND DISCUSSION

In order to predict conceptual model of SeulawahAgam volcano we used transverse electric (TE) mode data only. We believe that the targets sought in geothermal exploration are mostly conductors associated as the depth of the reservoir and cap rock. The TE mode data are mostly believed sensitive to the conductors. The TE mode data include apparent resistivity and phase were used for the inversion. The MT2DinvMatlab code developed by SeongKon Lee of Geothermal Resources Group, KIGAM, Korea was used for inversion. The apparent resistivity and phase data as well as the inverted 2D Model of electrical resistivity of SeulawahAgam sub-surface using MT2DinvMatlab shown in Figure 3. The apparent resistivity and phase data indicate the presence of resistive zones at a distance of 10-30 km along the profile. The similarities between the measured and calculated data showed a relatively good inversion process where 0.2 – 0.5 RMS have been reached during the inversion.
Figure 3 shows a comparison between measured and calculated data of apparent resistivity and phases along the profile. The area is dominated by both conductive and resistive zones. The inverted model shows a resistive zone at depth 200 to 800 meters and distance 10-25 km along the profile. The zone is predicted as cap clay layer with electrical resistivity values <10 Ohm-m. Geothermal reservoir is expected at depth of 1 to 4 km with resistivity values vary from 50 to 100 Ohm-m. The inverted model also shows fault area at distance 0 to 10 km along the profile where it indicates by low resistivity values. At the southern part of the profile is expected as recharge area.

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REFERENCES