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Analysis of Effect Rotation in 1D and 2D Magnetotelluric Data Models to Identify the "MR" Geothermal Field

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Abstract: *The magnetotelluric method is a passive geophysical method that utilizes electromagnetic waves and is effectively used in geothermal exploration. However, the measurement data with the MT method often causes distortion due to a mismatch between the expanse of the tool and the direction of the main structure of the study area. The existence of distortion in the measurement data can cause errors in modeling and interpretation. Therefore, this study aims to determine the effect of rotation on magnetotelluric data processing to produce an appropriate model, so that it can find out the "MR" geothermal system. Rotation is carried out on the sounding curve, with an angle of -45^o in accordance with the direction of the main structure of the study area. Based on the research that has been done the best model is generated from data that has been rotated because it produces smaller RMS and when compared with geological data has a more suitable model. The results of the interpretation show that the prospect of geothermal "MR" is estimated to be around the appearance of hot water manifestations, with the presence of a low resistivity (<10ohm.m) seen near the surface with a depth of 250 m which can be identified as a caprock. At a depth of 500 m it starts to show resistivity contrast which shows medium resistivity (20-150 ohm.m) to a depth of 1000 m which can be identified as a reservoir, and high resistivity (> 200 ohm.m) seen at depths of more than 1000 m which are zones predictable resistivity in response to rocks that might act as a source of heat from the "MR" geothermal system.*

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I. Introduction

The magnetotelluric method is the most effective method for geothermal exploration. However, the magnetotelluric method has disadvantages, namely data generated from the acquisition process often occurs distortion, due to the difference between the stretch of the tool at the time of acquisition and the condition of the dominant structure of the research area. Interpretation or modeling of distorted magnetotelluric data will result in incorrect model parameters. Therefore, to reduce errors caused by distortion, rotation of one component of the electric or magnetic field is carried out to be parallel to the structure, so that it is expected to produce a suitable model to facilitate the interpretation process.

This study uses MT geothermal area data "MR". The most important step in this research is to do a comparison on the model with data that has been rotated with a model that is not rotational. The magnitude of the rotation angle is determined using the help of the geological map of the research area, so that it is expected to produce a model that matches the actual conditions.

Magnetotelluric (MT) is an electromagnetic (EM) method that involves the natural measurement of the E electric field, and the H magnetic field, which can determine the conductivity of the earth's structure at depths ranging from several tens of meters to several hundred kilometers. Magnetotelluric (MT) is one of the passive geophysical methods, so the data generated at the time of acquisition depends on the response under the surface of the earth [1]. Impedance tensor is the relationship between an electric field and a magnetic field perpendicular to each other in the frequency domain [2].

At the time of MT data acquisition there is often a discrepancy between the expanse of the tool and the structure in the research area. Therefore, an important step in processing MT data is rotating one or the electric or magnetic field component or commonly called impedance rotation tensor [3].

II. Material And Methods

The data used in this study are secondary data obtained from the Coal and Geothermal Resource Center (PSDMBP) Bandung. The data that becomes the input to the processing is the parameter site data for each point, instrument calibration data and sensor calibration data. The data is processed by 19 points and two trajectories in

Southwest - Northeast which are perpendicular to the main structure of the study area. Based on a survey conducted by the PSDBP team in 2017 along the track there are hot water manifestations as seen in fig 1.

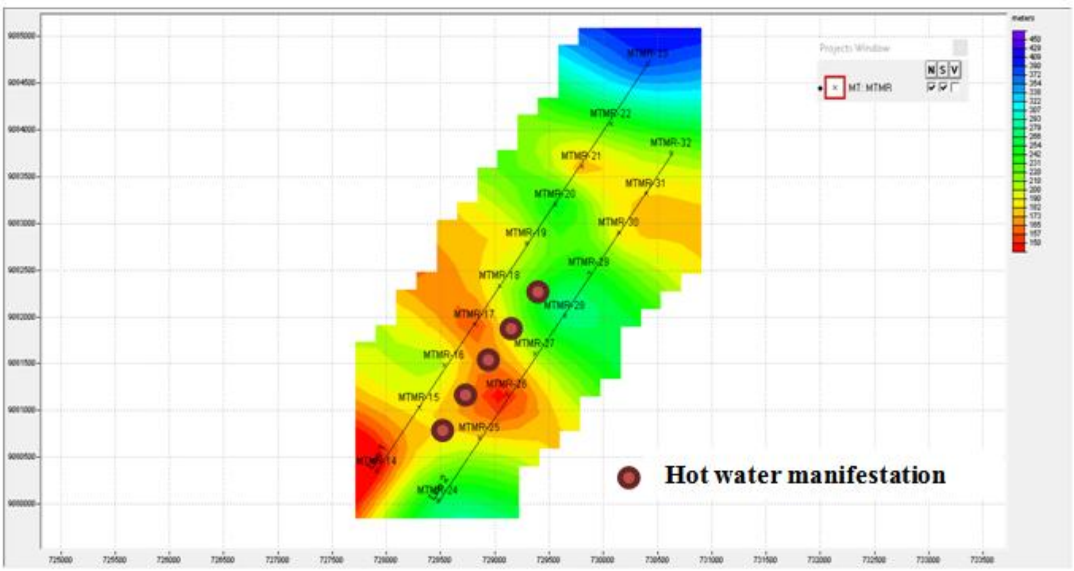


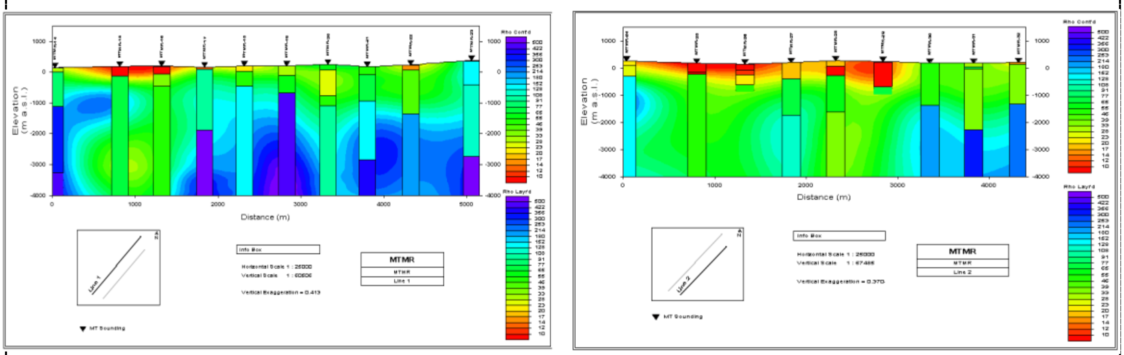
Figure 1. Base map distribution of research points

In this study the rotation stage was carried out on WinGLink software on a sounding curve of -45^0, because the main structure in the study area was Northwest - Southeast. This rotation means using the assumption of TE mode (Transverse Electric) which means the electric field is parallel to the main structure. After rotating the sounding curve, then do 1D and 2D modeling.

III. Result and Discussion

1.1. 1D Model

Model 1 -D serves to describe variations in resistivity only with depth. In this study the inversion used in the 1D model is Occam's inversion. This is because the Occam inversion is used more than the Bostick inversion so it can better describe the resistivity variation to depth. So the 1D modeling used for reference in 2D modeling is Occam's 1D model as seen in fig.2

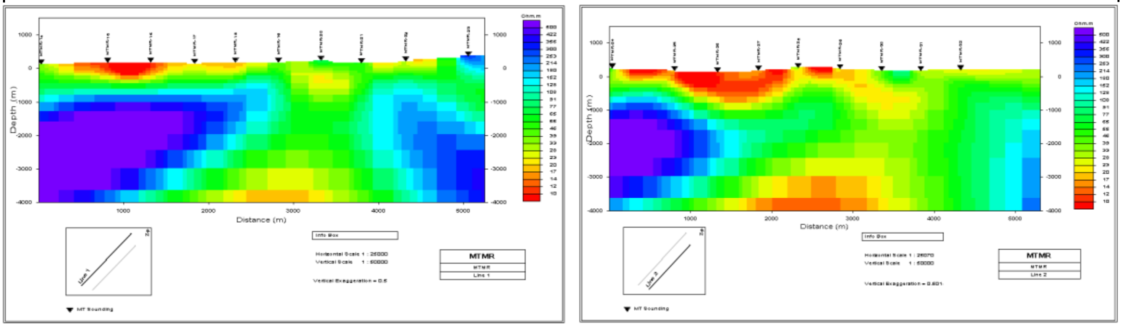


(a). (b).

Figure 2. Occam's inversion 1D cross section model (a). on line 1, (b). on line 2

1.2. 2D Model

2D inversion model describes the structure of subsurface resistivity to depth and distance so that the resulting model is clearer and easier in interpretation. The first step is to make the initial model or mesh arranged so that the rows and columns are not too tight and not too tenuous. Mesh that is too tight will cause the inversion process to last a long time, even though the 2D model will look smooth. While the mesh that is too tenuous will have an impact on 2D models that look rough even though the time required for inversion is faster. After the mesh is finished, the next step is to set parameters for 2D modeling by selecting the invertion menu, then setting and then setting the parameters listed, such as know value, data error, floor error and so on. In this processing, the tau value used is 3. The tau value is selected based on the L curve which reflects the value of roughness to the RMS, by selecting tau value which is at an angle or in the sense that it has a small RMS and roughness value [5]. Error data used is 10 for rho and 5 for phase. And the error floor used in this modeling is 5 for the rho value and the phase. The modes in this modeling all use TE-TM (invariant). The results of modeling 2D cross section of subsurface resistivity are shown in Fig. 3.

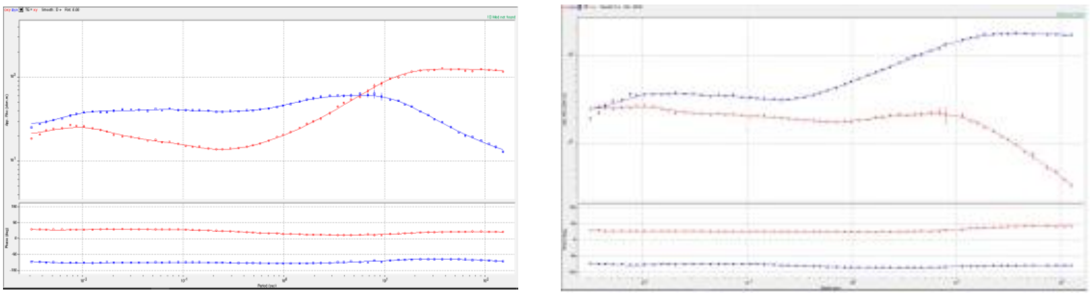


(a). (b).

Figure 3. 2D cross section model (a). on line 1, (b). on line 2

1.3. Effect of Rotation on MT Data Modeling

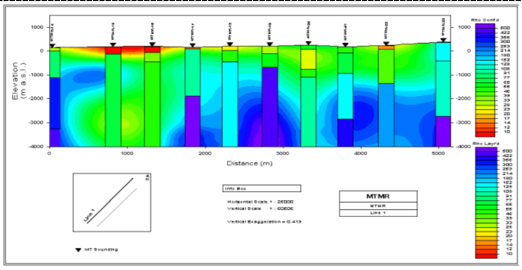
Based on 1D and 2D modeling that has been done on data that is not rotated and data that has been rotated results in a different model of distribution of resistivity. The rotation value given affects the impedance value, so the impedance value obtained in the data without rotation with the rotated one is different. The impedance value obtained influences the value of apparent resistivity or apparent resistivity curve used for modeling. The difference in pseudo resistivity curve on data that is not rotated with rotated data is shown in fig. 4.



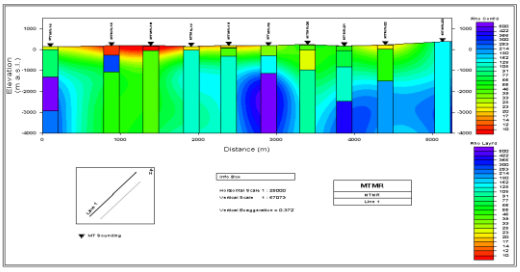
(a) (b)

Figure 4. Pseudo resistivity curve (a). on data without rotation, (b). rotated data

The difference in the resistivity curve shown in the image above will affect the 1D model as shown in fig 5. The results of the rotation of the data on the main structure also affect 2D modeling as shown in fig. 6.

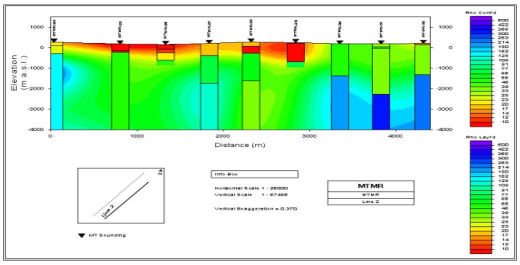


without rotatio

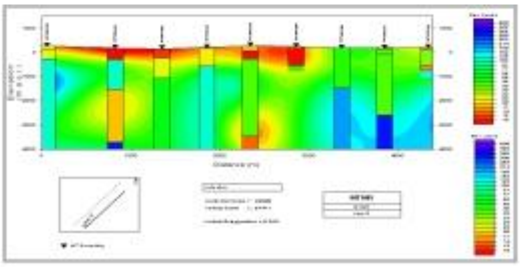


rotation

(a)



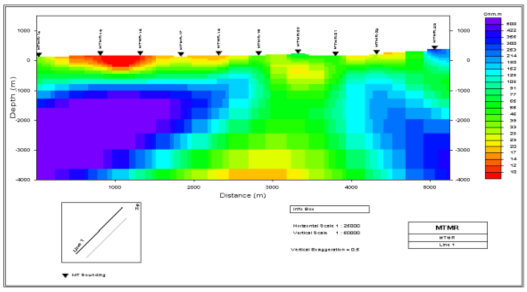
Without rotation



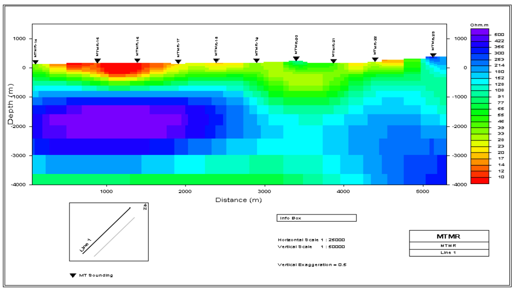
rotation

(b)

Figure 5. Differences in 1D models on data without rotation with rotated data (a). on line 1, (b). on line 2

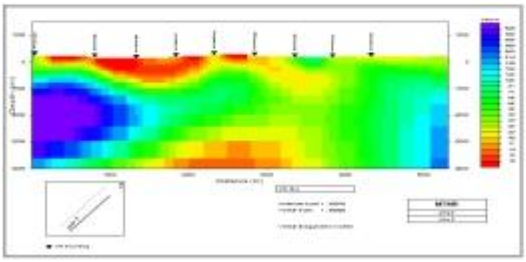


Without rotation

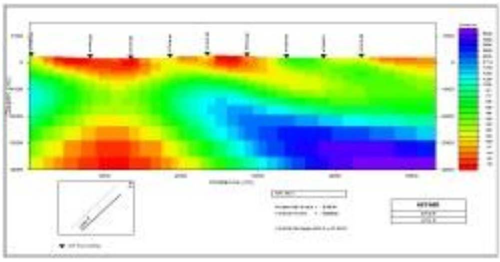


rotation

(a)



Without rotation



rotation

(b)

Figure 6. Differences in 1D models on data without rotation with rotated data (a). on line 1, (b). on line 2

From the results of the comparison of two different models, it can be seen that the model matches the geological conditions of the study area, namely the model that has been rotated towards the main structure. Quantitatively the model on the data carried out in rotation produces a smaller RMS value which indicates the resulting model represents more actual geological conditions. RMS (root means square) is the average of the misfit or difference between the acquisition data and the calculated data, so that the smaller the RMS shows that the model is getting better. Qualitatively the model on rotated data illustrates the contrast of clearer resistivity, making it easier to interpret. From these results it can be concluded that rotation is very important for modeling magnetotelluric data. Data without rotation often causes distortions that can cause errors in the process of modeling and interpretation.

1.4. Model Interpretation

Interpretation was carried out on model 1 and track 2 which had been rotated to the main structure. The prospect of geothermal MR is estimated to be around the appearance of hot water manifestations, with the presence of a low resistivity (<10ohm.m) seen near the surface along the southwest-northeast trajectory to a depth of 250 m which can be identified as a caprock. At a depth of 500 m it starts to show resistivity contrast which shows moderate resistivity (20-150 ohm.m) to a depth of 1000 m which can be identified as a reservoir of geothermal systems "MR". High resistivity (> 200 ohm.m) is seen at a depth of more than 1000 m which is a resistance zone which can be expected as a response from rocks that might act as a heat source from a geothermal system MR. The interpretation of the model on lines 1 and 2 is shown in Figure 7 and Figure 8.

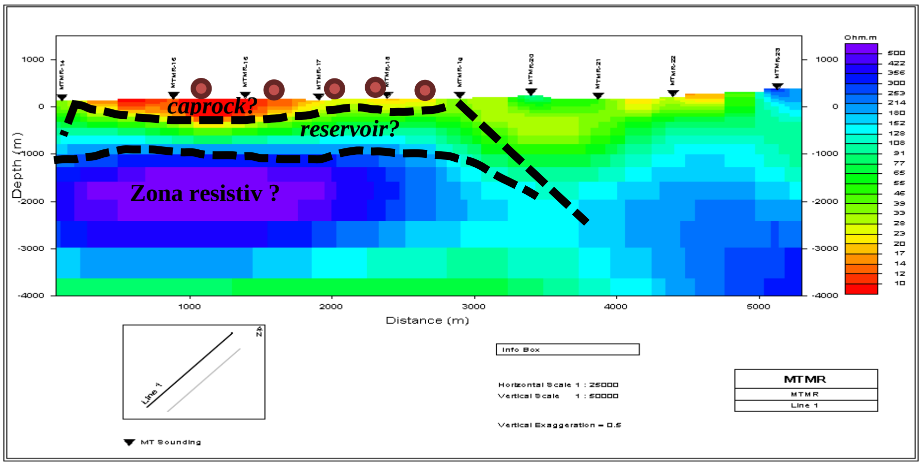


Figure 7. Interpretation of model line 2

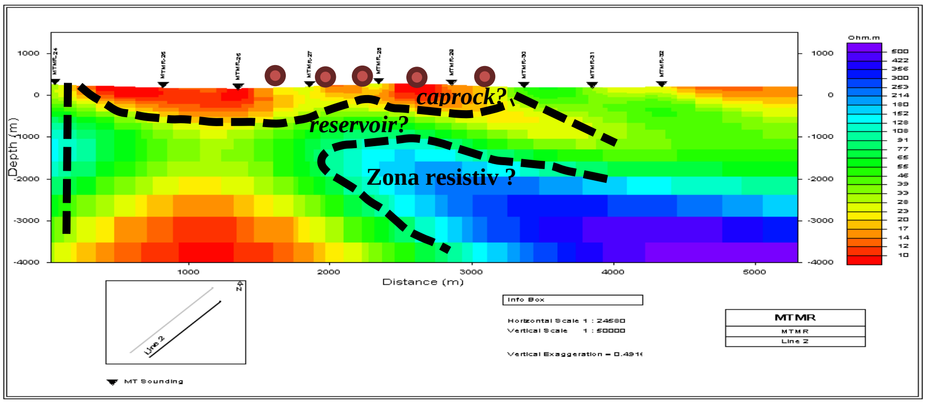


Figure 8. Interpretation of model line 2

IV. Conclusion

The Model shows coincide well to the geological conditions of the study area are obtained on the model that has been rotated towards the main structure. The rotation value given affects the assumption of the impedance value. The impedance values obtained affect the value of apparent resistivity or apparent resistivity curves used for 1D and 2D modeling. The geothermal prospect MR is estimated to be around the appearance of hot water manifestations, marked by a low resistivity (<10ohm.m) seen near the surface along the southwest-northeast trajectory to a depth of 250 m which can be identified as a caprock. At a depth of 500 m it starts to show resistivity contrast which shows moderate resistivity (20-150 ohm.m) to a depth of 1000 m which can be identified as a reservoir of geothermal systems MR. High resistivity (> 200 ohm.m) is seen at a depth of more than 1000 m which is a resistance zone which can be expected as a response from rocks that might act as a heat source from a geothermal system MR.

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