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Determination of Geological Strike Based on Magnetotelluric's Polar Diagram and Geological Condition in Tangkuban Parahu's Geothermal Area

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Abstract. In geothermal exploration, magnetotelluric method (MT) has the capability to resolve conductive body which then can be interpreted as cap rock. A reliable representation of the Earth's resistivity dimensionality can be achieved by incorporating the direction of geoelectrical strike and geological condition in the geothermal area. In this study, the magnetotelluric method was applied in Tangkuban Parahu volcanic area to reveal the subsurface structure of the area. Due to the uncertainty of MT modelling result, dimensionality analysis (polar diagram) is performed to find out MT data characteristic prior to MT inversion modelling. After that, lineament is mapped based on elevation map to estimate geological strike. Both methods are validated by geological condition in Tangkuban Parahu. The result of polar diagram analysis shows that the direction of geoelectrical strike is dominated NE-SW in mostly frequency and the result of lineament shows similar direction with polar diagram analysis as plotted in rose diagram yields about N45^{o}E.

1. Introduction

One of the most important thing in magnetotelluric (MT) modelling is representation of subsurface resistivity structure by doing dimensionality analysis [1]. However, observed data is still affected by noise. Occurrence of noise can mislead real dimensionality in subsurface until doing misinterpretation. Based on the problem, MT dimensionality analysis is performed to reveal dimensionality of subsurface structure and also geoelectrical strike direction which is not affected by noise.

After doing MT dimensionality analysis, lineament is performed to predict regional geological strike. Geological strike is direction of the line formed by the intersection of a fault, bed, or other planar features and a horizontal plane. Strike indicates the position of linear structural features such as faults, beds, joints, and folds. Geological strike is assumed having similar rock conductivity.

In this study, we identify strike based on MT dimensionality analysis especially polar diagram and lineament. According to both methods, they will be validated by geological condition in the study area.

2. Methods

2.1. Dimensionality MT
MT dimensionality analysis is done to find out information beneath MT data and being useful as a priori to MT inversion modelling. Dimensionality MT can be analysed from skew, polar diagram, Tipper, induction arrow, and phase tensor [2]. For this research, polar diagram is analysed.

2.2. Polar Diagram
Polar diagram is necessary to analyze unknown geoelectrical strike as doing MT data acquisition. The dependence of the impedance tensor upon the direction can be displayed as polar diagrams [3].
Let the tensor,

$$[\boldsymbol{Z}] = \begin{bmatrix} \boldsymbol{Z_{xx}} & \boldsymbol{Z_{xy}} \\ \boldsymbol{Z_{yx}} & \boldsymbol{Z_{yy}} \end{bmatrix} \quad (1)$$

Equation 1 represents the unrotated impedance tensor and needs to get rotated through an angle α in clockwise direction. The rotation operator is

$$[\boldsymbol{R}(\boldsymbol{\alpha})] = \begin{bmatrix} \cos\boldsymbol{\alpha} & \sin\boldsymbol{\alpha} \\ -\sin\boldsymbol{\alpha} & \cos\boldsymbol{\alpha} \end{bmatrix} \quad (2)$$

From equation 1 and 2 will be obtained a rotated impedance tensor turning into new axis x', y'. The rotated impedance tensor is

$$[\boldsymbol{Z}(\boldsymbol{\alpha})] = [\boldsymbol{R}(\boldsymbol{\alpha})][\boldsymbol{Z}][\boldsymbol{R}(-\boldsymbol{\alpha})] \quad (3)$$

Polar diagram is one of dimensionality data MT analysis that has not structural or frequency limitations [3]. If polar diagram drawn as a circle, it shows 1D character. The polar diagram ellipse-shape indicates 2D character while the peanut-shape represent a 3D character. In geothermal exploration, polar diagram can be applied to find out geoelectrical strike and complexity in subsurface. [4]

3. Results
Based on dimensionality MT data analysis using polar diagram, it can determine dominated geoelectrical strike and describe about complexity in subsurface. For resistive materials, major axis of the polar diagram is perpendicular to the strike direction. Meanwhile, on conductive medium, major axis of the polar diagram is parallel to the strike [4].
Figure 2 shows polar diagram in 100 Hz overlaid to geological regional map in order to correlate with lithology in Tangkuban Parahu. Figure 3 shows polar diagram in 10 Hz overlaid to geological regional map and get assumed as a medium depth. Figure 4 shows polar diagram in 0.1 Hz overlaid to geological regional map and get assumed as a deeper depth.

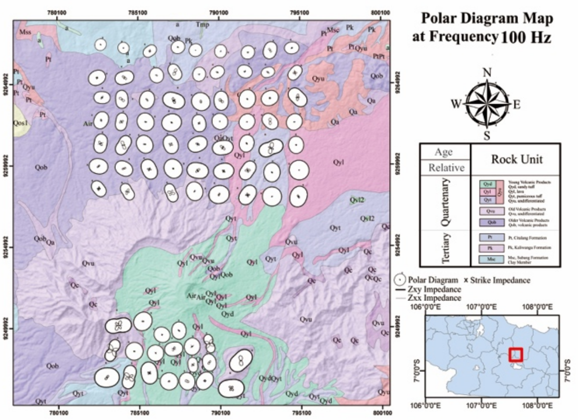

Figure 1. Polar Diagram at 100 Hz in Tangkuban parahu

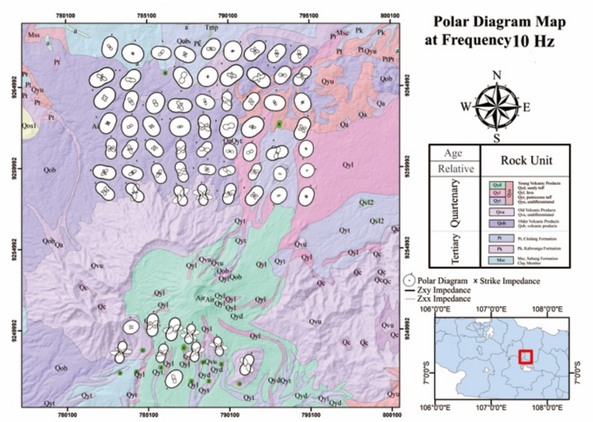

Figure 2. Polar Diagram at 10 Hz in Tangkuban parahu

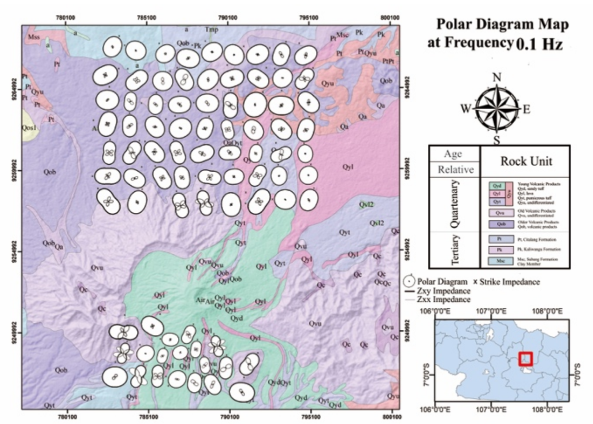

Figure 3. Polar Diagram at 0.1 Hz in Tangkuban parahu

Figure 2 shows on northern of Tangkuban Parahu is classified with MT-1D data dominantly. The polar diagram for |Zxx| collapses to a point, while the polar diagram for |Zxy| forms a circle.
These patterns are interpreted as resistivity varies to depth only in shallow depth. On southern of Tangkuban Parahu sense similar expression that MT-1D data dominantly and minor MT-2D data. At frequency intervals 320-100 Hz are achieved that 60% oriented strike NE-SW.

Figure 3 shows on the northern part is classified with MT-1D data dominantly and minor MT-2D data. On the southern part is classified with MT-2D data and minor MT-3D data. The polar diagram for |Zxx| forms a flower with four petals, while the polar diagram for |Zxy| forms an elipse. These patterns are interpreted as resistivity varies to z-axis and y-axis in medium depth. At frequency intervals 10-1 Hz are achieved that 70% oriented strike NE-SW.

Figure 3 shows on the northern part is classified with MT-1D data dominantly and minor MT-2D data. On the southern part is classified with MT-3D data and minor MT-2D data. The polar diagram for |Zxx| forms asymmetric flower and open out from ‘peanut’ shape, while the polar diagram for |Zxy| forms a ‘peanut’ shape. These patterns are interpreted as resistivity varies to x, y, z-axis. It tells that complexity in subsurface is heterogenous product. At frequency intervals 0.1-0.01 Hz are achieved that 75% oriented strike NE-SW.

According to Kartadinata (2004), lithology in that area is lava flow along NE-SW [6]. Therefore, geological condition in the research area is matching with polar diagram in magnetotelluric. From these results express similar strike orientation and then, they will be validated by identifying volcanic product orientation in Tangkuban Parahu.

4. Conclusion

Determination strike from polar diagram and lineament show similar strike orientation that is NE-SW. The result is confirmed to geological condition in Tangkuban Parahu oriented NE-SW as volcanic product flow according to Kartadinata (2004).

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