Article-18

Eco. Env. & Cons. 22 (1) : 2016; pp. (119-124)
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ISSN 0971–765X

Application of geoelectric method for environmental study of groundwater appearance in coal mine area

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(Received 23 October, 2015; accepted 20 December 2015)

ABSTRACT

Acid Mine Drainage (AMD) is caused by water flows over or through sulfur-bearing materials forming acidity solutions. The presence of groundwater in overburden layer influences the formation of AMD in contact with sulphide minerals and oxygen. This research was carried out to investigate the presence of groundwater by geophysical approach using 2D geoelectric resistivity measurement with Wenner-Schlumberger array. From 3 measurement lines, line 2 PIT 3 Timur has indication of groundwater appearance. It is shown by resistivity value range between 0.6 to 1 ohm meter. These results could be used by decision makers to carry out coal exploration securely avoiding contact between groundwater and rain water with sulphide minerals and oxygen.

***Key words** : Acid mine drainage, Ground water, Overburden layer, Geoelectric method*

Introduction

The presence of ground water of the overburden layer or overburden dump in the coal mining area becomes an environmental problem because it will trigger formation of acid mine drainage after coal exploitation. Groundwater together with rainwater and oxygen will oxidize the sulfide minerals of coal seam to generate acid mine drainage that is very harmful to the environment.

Determining the internal structure of overburden layer which can typically contain millions of tons of waste rock, and cover several hectares over a thickness of tens of meters, is a very challenging undertaking. Drilling in the coarse and highly heterogeneous material is difficult and expensive. On the other hand, non destructive, non invasive geophysical methods can be used to inexpensively map material properties to varying levels of resolution for a large volume of rock waste of overburden (Poisson *et al.*, 2008).

Geoelectric resistivity method is one method of geophysical measurements are widely applied to environmental problems such as the detection of wastewater and groundwater and geotechnical studies such as the bridge foundations and the landslide, because the geoelectrical method is capable of mapping both low and high resistive formations and therefore a valuable tool for vulnerability studies (Chistensen and Sørensen 1998, Sørensen *et al.*, 2005). The ground resistivity is related to various geological parameters such as the mineral and fluid content, porosity and degree of water saturation in the rock (Loke, 2000).

Methodology

Site Description

The investigated site is located at the West Banko

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mine, one of the coal deposits in the area of Tanjung Enim Indonesia (Fig. 1). This area is characterized by the layer slope that is fairly steep ranged 60^o - 80^o at PIT 3 and more gentle at PIT 1. It has influenced the design of the slope, especially for slope direction of the bedding.

The main layer group of West Banko coal consists of five layers, namely, Mangus Up (layer A1), Mangus Down (coating A2), Suban Up (layer B1), Suban Down (layers B2) and Petai (layer C). In general stratigraphic sequence and lihology colomn of Tanjung Enim is shown as Fig. 2.

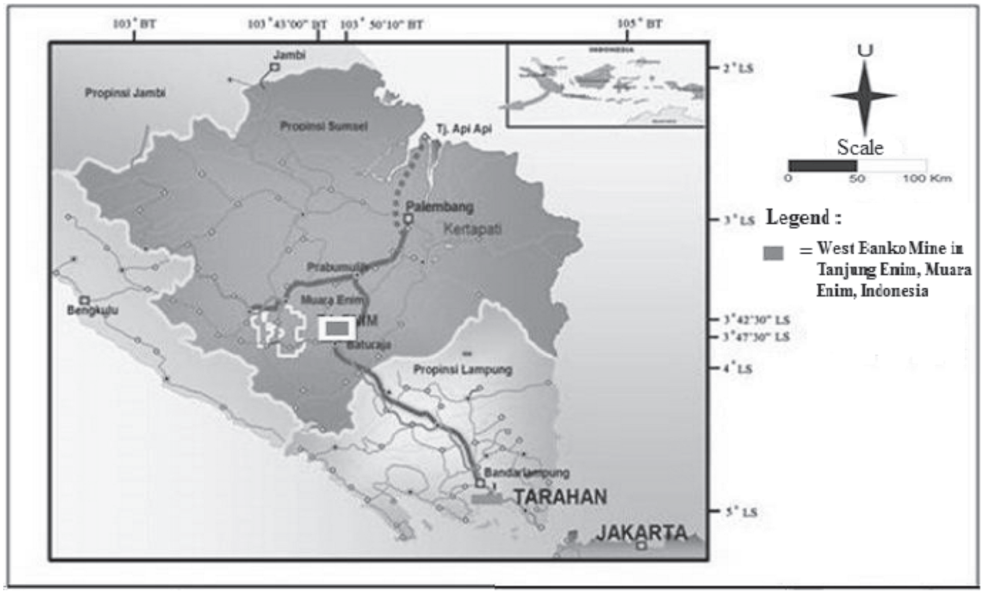

Fig. 1. Location Map of the Research

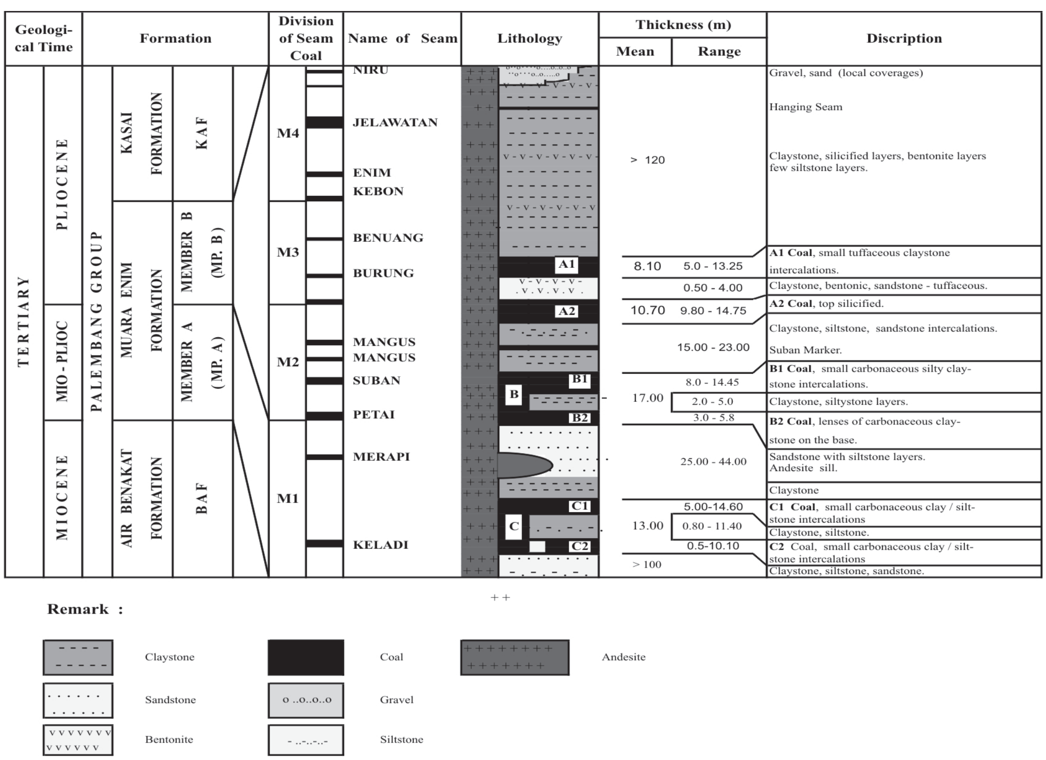

Fig. 2. Stratigraphic sequence and Lithology Colomn of Tanjung Enim

Method

In order to achieve the objectives of the research, field measurement was carried out using a multichannel geoelectric method of the Wenner-Schlumberger array. The tools used are unit of resistivitimeter MAE (Fig. 3). The measurement was performed for three lines, Line 1 PIT 3 Timur, Line 2 PIT 3 Timur and Line 1 PIT 1 Barat. One of the measurement lines is shown in Figure 4. Each line has a 144 meters long profile with 48 pieces of electrodes and the spacing between electrodes is 3 meters.

Fig. 3. MAE Geoelectric tool unit used with 144 meters cable length

Fig. 4. One of measurement Lines in West Banko

Wenner-Schlumberger array is a combination of Wenner array and Schlumberger array. This array has the sensitivity of resistivity variations laterally (Wenner array) and vertically (Schlumberger array). The Schlumberger method has a greater penetration than the Wenner. In resistivity method, Wenner configuration discriminates between resistivities of different geoelectric lateral layers while the Schlumberger configuration is used for the depth sounding (Olowofela *et al.,* 2005). So that the Wenner-Schlumberger array has a good coverage either laterally or vertically.

The 2D resistivity measurement results resistivity variations of the sub-surface. The resistivity measured is converted into a pseudosection contour. And using 2D iterative smoothness-constrained least square inversion it is acquired 2D cross section showing the actual resistivity variation of the subsurface. The data processing is done with the help of software Res2Dinv.

Results and Discussion

The results of the 2-D electrical resistivity surveys are presented as a measured, calculated apparent resistivity and the section of the inverted resistivity model as shown by Figure 5, 6 and 7. A contoured pseudosection conveys a qualitative two-dimensional variation of resistivity within the subsurface. And the section of the inverted model conveys true resistivity model within the subsurface.

Analysis of Line 1 PIT 3 Timur

1. Clay indicated as dark blue, light green, dark green and light blue that are on both sides of the cross section separated by the intrusion of sandstone has a resistivity range (1-100 ohm meter) depending on the water content. The lower water content the less resistivity value.

2. There are sandstone intrusion of 4 m - 23,6 m due to geological phenomena. Shown in yellow, brown to red with a resistivity range (200-8000 ohm meter) depending on the water content, the lower water content so the less resistivity value. This is reinforced by the position of sandstone that is far from the clay which has a high water content reaches 2062 ohm meter resistivity values (red).

3. The weathered Sandstone contaminated with basic soil, silt, andesite and gravel (material with a size of more than 4 cm) at a depth of 0-4 m is marked as brown, red and purple. Resistivity varies between 100-10000 ohm meter. High resistivity value indicates that the rocks that exist in the area are hard and compact (andesite).

Analysis of Line 2 PIT 3 Timur

1. The weathered andesite and shale are characterized as dark brown, orange, red, and purple. Generally in this research the indication is defined having

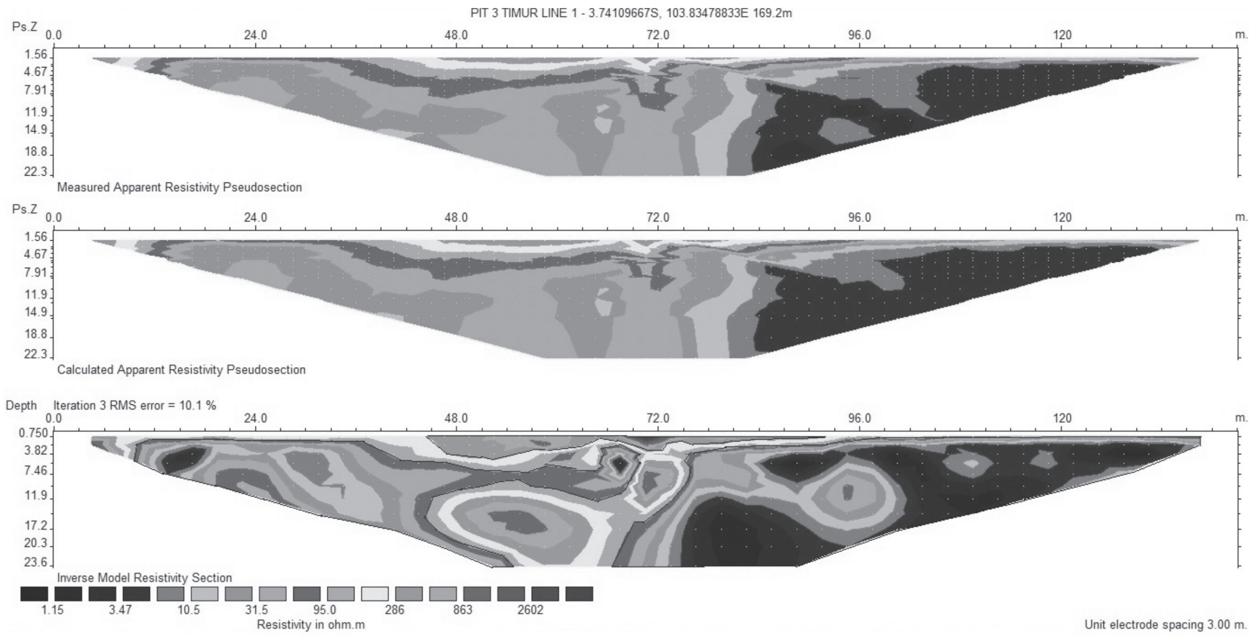

Fig. 5. Measured and calculated apparent Resistivity Pseudosection and Inverse Model Resistivity Section of Line 1 PIT 3 Timur.

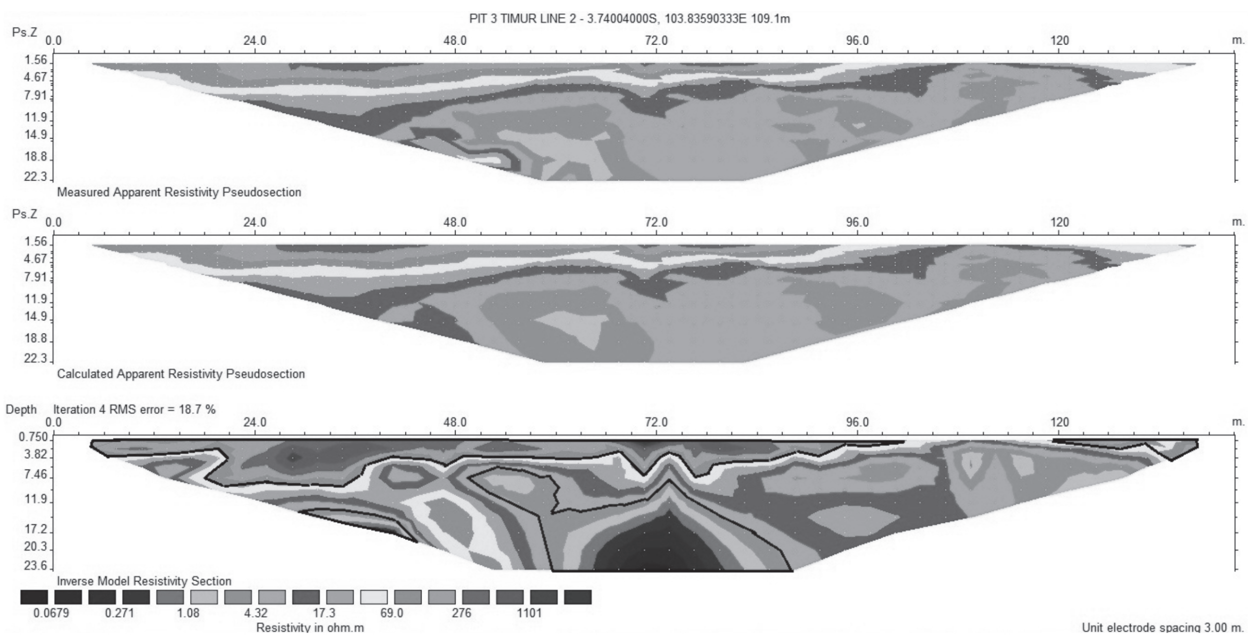

Fig. 6. Measured and calculated apparent Resistivity Pseudosection and Inverse Model Resistivity Section of Line 2 PIT 3 Timur.

a resistivity range of 100-10000 ohm meter until 8 meters depth.

2. Clay layers marked as green, yellow, and brown, are identified in accordance with resistivity range of 1-100 ohm meter. And in the present research it is in the range 2-100 ohm meter.

3. The light and dark blue are predicted as groundwater characterized by resistivity values from 0.06 to 1 ohm meter based on the data of the research area. It is predicted as sandstone which

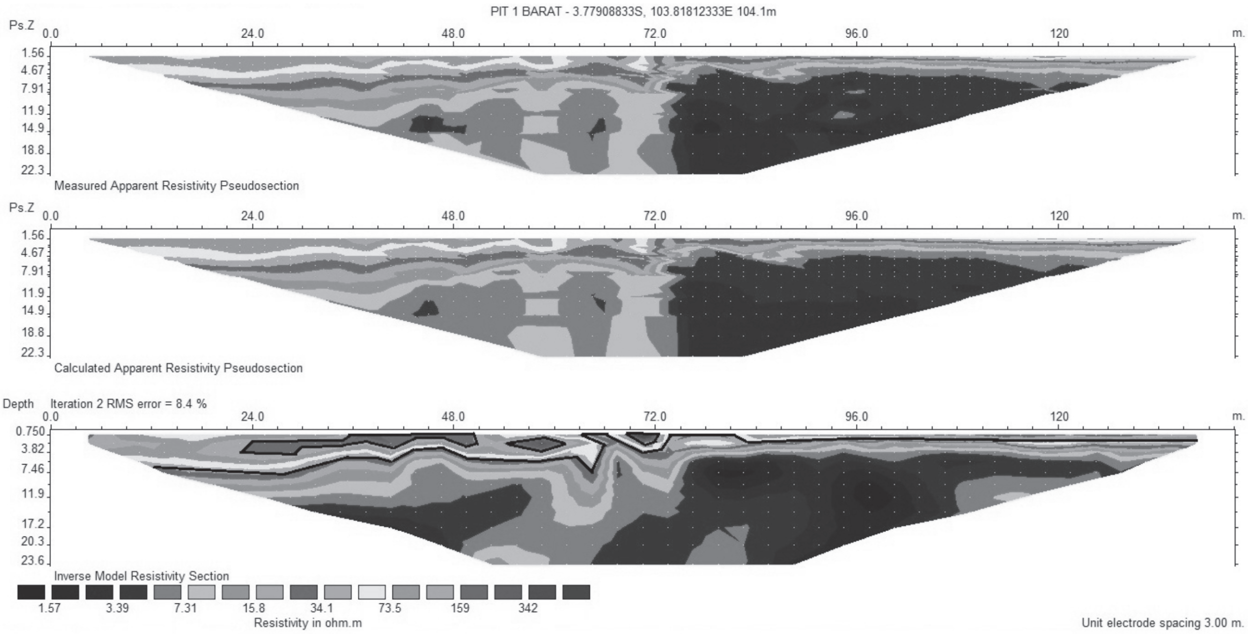

Fig. 7. Measured and calculated apparent Resistivity Pseudosection and Inverse Model Resistivity Section of Line 1 PIT

could be a groundwater reservoir. From the trend it is probably the shallow groundwater.

Analysis of Line 1 PIT 1 Barat

1. Gravel spread with red and purple is massive and contain no moisture. The resistivity range is 100-600 ohm meter in accordance with conditions of sunshine and dry soil.
2. Layer with a yellow-orange color is the top soil (soil) of the depth until 7 meters. Top soil resistivity ranges between 50-100 ohm meter under suitable conditions so that the dry soil resistivity measurements ranged between 70-100 ohm meter.
3. The thick clay layer that is green, light blue and dark blue has a resistivity range 1-100 ohm meter.

The results show that the appearance of ground water is only indicated in Line 2 PIT 3 Timur West Banko. The other lines only indicate the lihology such as claystone and sandstone. It means that excavation of coal should avoid the line 2 PIT 3 Timur at the depth below 11.9 meter to minimalize groundwater contact with sulphide minerals and oxygen causing acid mine drainage. Due to the increasing number of incoming water (groundwater or rain water) to interact with oxygen and sulphide minerals so the formation of acid mine drainage will be even bigger and worse.

This research is in accordance with the management of mining that suggests the importance of water management either groundwater or surface water to minimize the resulting environmental risks (BRGM, 2001).

Conclusion

The geoelectrical resistivity method is useful to delineate appearance of groundwater in overburden layer or overburden dump in coal mining area. Because the knowledge about the presence of groundwater can be used to avoid contact the groundwater or the rainwater with sulphide minerals and oxygen. This is one way of preventing the formation of acid mine drainage. Therefore, results of this research will be taken into consideration for decision makers in the coal mining industry to undertake coal exploitation securely so that it can minimize environmental risk.

Acknowledgement

The authors would like to thanks PT. Bukit Asam Tbk especially Division of Environmental Planning for the secondary data and the research permit in their coal mining area.

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