Environment management in prospect coal mining area at Handil Kutai Kartanegara, East Kalimantan using resistivity tomography, wenner configuration

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Abstract. The geoscanning method is a geophysical method that utilizes the nature of resistivity type to study the subsurface conditions of the earth. Resistivity resistance is an important parameter to characterize the subsurface physical state, which is associated with material and subsurface conditions.[1]. Based on an analysis of the distribution of this type of prisoner, furthermore we can be interpretation the conditions of under the earth's surface. The purpose of this investigation is to obtain information below the surface of the earth and coal targets contained in there using the Geoscanning method with Wenner configuration. Based on the results of 3 trajectory inversion of location of 1 resistivity tomography data, the best coal prospect area on line 1, line 2, location of 1 (Pit 10) with alluvium and hard material types. Only constraints on line 1, the coal prospects are covered by analysis of weak zones to the east, in the form of swamp soft soil with ground water classification - clay which is characterized by light blue - dark blue with resistivity values 10 - 34.7 ohms/metres to a depth of 30 metres. Whereas on line 2 which is adjacent to vico 1 and silk wells, the condition of the coal land was safe for exploration activities to a depth of 40 metres, without disturbing the oil well area, and far from the silk location, and the condition of the soil material is solid and no weak zone analysis is found. In the Pit 5 area on line 4, the prospect of coal mining is covered by a landslide-prone zone, where the mine location area (pit 5) is dominated by soft soil classification of sandstone material (resistivity 8.6 - 49.2 ohms/metres), blue - gray - light green along the long stretch of North - South direction along 240 metres with a depth reaching 24 metres. This area has the prospect of coal having a moderate resistivity (including small for the quality of coal), namely the range 76 - 182 ohms/metres, marked by red - orange - yellow, with a target depth of up to 39.4 metres.

1. Introduction
The geoscanning method is a geophysical method that utilizes the nature of resistivity type to study the subsurface conditions of the earth. Resistivity resistance is an important parameter to characterize the subsurface physical state, which is associated with material and subsurface conditions.[1]. Based on an analysis of the distribution of this type of prisoner, furthermore we can be interpretation the conditions of under the earth's surface. The purpose of this investigation is to obtain information below the surface.
of the earth and coal targets contained in there using the Geoscanning method with Wenner configuration. The scope of this investigation is to take Geoscanning data with Wenner configuration and doing a several data processing, so that the resistivity tomography value, type of soil, and depth are obtained. After all the information above has been obtained, we are able to explore coal mineral rocks to the maximum and can be manage the environment after exploration better, to avoid the risk of landslides and subsidence.[5].

2. Research method
Method of this research are:

1. The investigation was carried out for 4 days. The first stage is induction for occupational safety on October 21th, 2018. On the second day, we recognize the location of the investigation on October 22th, 2018. Then the next stage is data collection from October 23th to October 24th 2018.

2. The location of the investigation is at the coal mining site, Handil, Muara Jawa Kutai Kartanegara, East Kalimantan. While data processing and interpretation are carried out at the office of PT. Putra Cipta Jaya Consultant on October 25th to November 9th, 2018. Flowchart of the research methodology in Figure 1.

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**Figure 1.** Flowchart of the research methodology
3. Theoretical basis

3.1. Definition of Wenner Configuration

For this resistivity tomography measurement, the Wenner configuration methods are used [1]. In Wenner's configuration, the current electrode and potential electrode are placed as shown below:

![Picture 2. Wenner Configuration](image)

where ‘a’ is the distance between electrodes whose the values changes depending on the desired stretch. Every changes in the value of ‘a’, then the datum point will be different. In this investigation, the distance between electrodes is 6.5 meters and its multiples is up to approximately 247 meters in length. [1]. When all field data is obtained, the next step is processing data. Readable current and voltage values in the tool will be used to calculate the apparent resistivity, after multiplying by the geometry factor (K). The equation to get the value of apparent resistivity is:

\[
\rho_a = K \frac{V}{A}
\]

with :
- \( \rho_a \) : Apparent Resistivity (Ohm.m)
- \( V \) : Voltage (mV)
- \( A \) : Current flow (mA)
- \( K \) : Geometric Factor Wenner (metre)

3.2. The Instrument for Measurement

The instrument for measurement are Ares Geoscanning which is used digitally. The measurement steps are as follows:

1. Geoscanning Ares, which the electrode configuration can be selected through a tool system, which its tool are used for writing the current which its be injected into potential earth. The measurements in this area use the selection of the Wenner configuration method.
2. Switch box, as an active electrode position modifier tool.
3. Accu 12V, as a DC current source injected into the earth.
4. 48 pieces of electrode, as a conduit for the current and voltage of the measuring device.
5. The cable is equipped with a meter to measure spacing, and connecting electrode with a switch box.
6. Hammer, as a tool to deepen the position of the electrode when injected into the ground.
7. Global Positioning System (GPS), as a tool to find and determine the position and elevation of electrodes.
8. Handy Talky, as a field communication tool.
3.3. *The Procedure of Geoscanning Measurement*

The procedure for measuring geoscanning includes [5]:

1. Placed the instrument in a specified location.
2. Connected the Resistivity meter, switch box, and 12V battery with connecting cable.
3. Plugged the electrodes at points marked with wooden stakes.
4. Expanded the cable that has been marked by the meter length, then connected into the electrodes. Electrodes are stretched 24 electrodes (total track length 120 meters) to the east, and 24 electrodes (total track length 120 meters) to the west with a depth target of 40 metres. The installation of electrodes starts with a small number electrode.
5. Connecting the parent cable to the positive and negative poles to the switch box and be continue connected into the geoscanning device and batteries. The function of the switch box is to detected the displacement of the subsurface current automatically, and later, this transfered will be read on the geoscanning tools. The geoscanning tool is able to read and record current transfer and potential differences digitally.
6. Calibration all the potential electrodes. If there were obstacles (example there were electrodes that were not measurable) its usually be read on the device, which was indicates an error in the electrode in question. If this happens, then the electrodes was checked, justified, then calibrated again. Calibration will be done for three times. If three times there is still an error electrodes, then we did a dummy, that was the electrodes with the error is ignored. Because, in inversion processed, an error in one data will not affect the process of data accurated, in the other words, the inversion results still display a good subsurface section.
7. If the calibration has been done, then we will started to collected data in the field. Inputting location points and configuration selection was done digitally.

**Figure 3.** Geoscanning Ares tools with the switch box digitally

**Figure 4.** Data that was read in the tools
Figure 5. Data collection process for Location 1 near swamp forest (Pit 10) in the West-East direction.

Figure 6. Data collection process for Location 2, near the wells of Vico 1 (North) and High Voltage (South) (Pit 10).

Figure 7. Data collection process for Location 3, near the well of Vico 2 (West) and Forest (East) (Pit 10).
3.4. Data Processing
To process the initial data, we used the Microsoft Excel tool to calculate the apparent resistivity at each of datum point. After the apparent resistivity obtained, the value was made in the Notepad format according to the data input format from the software that will be used for data processing. In this Notepad must also be filled with topographic values, so that after being mapped by Res2dinv a resistivity cross section will be obtained topographically classified. In addition, in the Res2dinv program data editing is done to eliminated datum points which are considered not good, and then resulted a cross section of inversion with a low error value.[2].
The value of the red circle was datum point with a poor value so it was necessary to exterminated a bad datum point option. The next step was did an inversion at the data path using Res2dinv with the Least-Squares Inversion method. The results obtained in the form of cross section resistivity. This section of resistivity contains information about the value of resistivity, number of electrodes, and estimated penetration depth of measurement. Figure 10. Was an example figure data processing result using Res2dinv software.

![Figure 10](image-url)

**Figure 10.** Cross section Inversion data using Res2Dinv. a). Cross section before topographic correction b) Cross section reverse after topographic correction.

After all the trajectory data has been processed, an interpretation can be made to explain the values in the geophysical parameters visualized in a two-dimensional cross section into the geological language which related to the presence of rocks under the surface.
4. Result and discussion

Figure 11. Map Location of 1  (Pit 10 Coal Mine) where there are 3 tracks that will be measured geoscanning.

Figure 11. shows the geoscanning trajectory at the location of 1 mine area Pit 10. The blue color shows the trajectory area that is visible on the surface with the West - East direction. Its Field conditions was full of alluvial soil and swampy nipah forests, which are located on track 1.[3]. Whereas track 2 shows the track conditions that are adjacent to the oil well of Vico 1. The land area is dominated by landfill and solid rocks. Track 3 is an adjoining area with a vico 2 well. The condition of the land here is dominated by soft soil.[4].

Figure 12. Map Location of 2 (Coal Mine, Pit 5)

Figure 12. shows the geoscanning trajectory in the location of 2 Pit 5 mining areas. On this land, it has been opened as a mining activity, there are only a few slope conditions that are somewhat landslide, North-South direction. The dominant soil conditions are volcanic soil and soft soil.[4]. After the trajectory process was carried out, we taken the data, both resistivity and coordinate data. After that, we continued with data inversion so that it could be shown a figure of its the subsurface
layers. The display of its subsurface section are as follows:

![Cross section of inversion results in Line 1 Location of 1 (Pit 10)](image)

**Figure 13.** Cross section of inversion results in Line 1 Location of 1 (Pit 10)

Figure 13. Shows the inversion results of trajectory 1 tomography resistivity data, with a track length of 240 metres. Analysis of coal which is described in purple-red - orange - to yellow is quite high in the west, up to a depth of 39.4 - 40 metres, the resistivity is 199 - 637 ohms/metre. But the obstacle is that this part of the coal is covered by analysis of the weak zone to the east, in the form of swamp soft soil with the classification of ground water - clay characterized by light blue - dark blue with a resistivity value of 10 - 34.7 ohms/metre to a depth of 30 metres. [4].

![Cross section of inversion results in Line 2 Location of 1 (Pit 10)](image)

**Figure 14.** Cross section of inversion results in Line 2 Location of 1 (Pit 10)

Figure 14. Shows the area of prospects for good and wide coal marked in purple-red - orange - to yellow, with resistivity 120 - 733 ohms/metres. The entire stretch from North - South is 240 metres long and is dominated by coal mines, classification of alluvial, and solid materials, to a depth of 40 metres from the surface.[3]. The sedimentary rocky soil of shale material is dense, depicted in dark green - light green with a range of resistivity prices of 32 - 64 ohms/metres. The depth up to 30 metres from the
surface. In this area there was no soft soil, mud or swamp soil, and ground water material. If there were soft soil only very few in number. This area was beside to the VICO 1 well and high voltage. But there was no weak zone in this area so that mining exploration is safe.[4].

Figure 15. Cross section of inversion results in Line 3 Location of 1 (Pit 10)

Figure 15. Shows the results of inversion of resistivity tomography trajectory data line 3. Resistivity values weaken between 4-64 ohms/metres represented by blue to green West-East direction, ranging from a stretch of 45 - 240 metres on a surface with depth of up to 40 metres, with soil classification soft, classification of ground water material, in the form of swamp areas and mud deposits.[4]. While there is a high resistivity value (24 - 512 ohms/metres) in the West which is the prospect of coal, and this is very little, 80 metres in length on the surface and the depth of the coal prospect is very short only up to 12.4 metres shown in purple - orange - yellow. This area is adjacent to the VICO 2 well. And it is dominated by weak zones, as well as few coal prospects.

Figure 16. Cross section of inversion results 4 Location of 2 (Pit 5)

Figure 16. Area of mine site (pit 5) which is dominated by soft soil classification of sandstone material (its resistivity is 8.6 -49.2 ohm/metres), colored blue - gray - light green along a long stretch of North - South along 240 metres with the depth reaches 24 metres. [4]. This area has the prospect of coal having a moderate resistivity (including small for the quality of coal), namely the range 76 - 182 ohms/metres, marked by red - orange - yellow, with a target depth of up to 39.4 metres. Because this area is dominated by soft soil, landslides are prone to occur in the implementation of exploration activities.
5. Conclusion and suggestion

5.1. Conclusion
From the description of the results and discussion above, the writer can draw conclusions:

1. Based on the results of 3 trajectory inversion of location of 1 resistivity tomography data, the best coal prospect area on line 1, line 2, location of 1 (Pit 10) with alluvium and hard material types. Only constraints on line 1, the coal prospects are covered by analysis of weak zones to the east, in the form of swamp soft soil with ground water classification - clay which is characterized by light blue - dark blue with resistivity values 10 - 34.7 ohms/metres to a depth of 30 metres. Whereas on line 2 which is adjacent to vico 1 and silk wells, the condition of the coal land was safe for exploration activities to a depth of 40 metres, without disturbing the oil well area, and far from the silk location, and the condition of the soil material is solid and no weak zone analysis is found.

2. In the Pit 5 area on line 4, the prospect of coal mining is covered by a landslide-prone zone, where the mine location area (pit 5) is dominated by soft soil classification of sandstone material (resistivity 8.6 - 49.2 ohms/metres), blue - gray - light green along the long stretch of North - South direction along 240 metres with a depth reaching 24 metres. This area has the prospect of coal having a moderate resistivity (including small for the quality of coal), namely the range 76 - 182 ohms/metres, marked by red - orange - yellow, with a target depth of up to 39.4 metres.

3. Overall the resistivity tomography obtained is quite good. After going through the data processing and inversion, the smallest error value is 5%. Data processing is very good, with inversion success rates of up to 95%. So that it can be said that the results of the data processing display are accurate to be used as a reference for exploration activities.

5.2. Suggestion
The results of the resistivity tomography analysis should be developed by improving the structure of civil engineering on this prospect mining coal area to eliminate the risk of landslides and subsidence.

6. References
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