Geo-Electric Resistivity Method of Dipole-Dipole Configuration For Cavities Model 2D in Karst Area of Temurejo Village Gubug Sub-district Central Java District

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Abstract: The purpose of this research is to mapping cavities in karst area in Temurejo Village, Karangrayung, Grobogan using geoelectric resistivity method and dipole-dipole configuration. Measurement consist of six lines using Multichannel S-Fields geoelectric instrument. Apparent resistivity data processing use two software, Res2DInv ver. 3.56.22 and Voxler 4.0. The result is lithology of the research location can be interpret consist of sand-silt, carbonate-silt rock, carbonate-sand rock, and carbonate rock with resistivity range 15,3-4919 Ωm. There are resistivity value anomaly in line of 1,2,3,4,5, and 6 on the carbonate rocks layer, the value is more than 4949 Ωm which can interpret as a cavity. On the first line, cavities are at depths of 20 m and 12 m, on second line are at depths of 17 m and 12 m, on third line is at depth of 19 m. Cavity continuously at depth of 18 m on fourth, fifth and sixth lines. This cavities at the depth >23 m beneath eath surface.

Keyword : Geoelectric resistivity, karst area, cavities.

1. Introduction

Karst is a term used to describe a limestone field, having unique characteristics, characterized by a rare surface water flow, a thin soil solum and sometimes only in certain areas, a more dominant underground water flow than with the flow of water on the surface. The formation of alleys and cracks on the surface causes the water directly into the underground flow system resulting in dry conditions on the surface (Murti, 2009).

The karst area is made up by very porous limestone so the water is so easy to seep and pass through. Certain limestone depths, often found in large quantities of water, are found in the cracks, fractures and dungeons (caves) and that flow as underground rivers and come out as springs (Sulistyorini, 2014). The karst landscape area physically exhibits dry and arid conditions, but beneath the surface there is a potential source of water and there are several springs and has been utilized as a source of clean water by PDAMs that can supply the surrounding villages and reconstructions in the lower terrain (Ruswanto *et al*., 2008).

Karst area formed from limestone and napal scattered huddle forming hills, one of them in the Village District Temurejo Karangrayung. The kasrt area in this village forms an elongated hill that has been used for mining purposes. In addition the general characteristics of the formations on limestone are luweng and springs. (Ridarso, 1996). There are many springs in Temurejo Village that indicate the presence of an underground river in the area.

To find out the existence of underground rivers in the village it is necessary to research. The method used to determine the physical properties in the earth is the geophysical method. Geophysical method is the study of the earth with the use of physical measurements on or above the surface. On the other hand, geophysics studies all the contents of the earth whether visible or not directly visible by the measurement of physical properties with adjustments that are generally on the surface (Dobrin & Savit, 1988). Geo-electric method is one of the geophysical method to know the change of resistance of type of rock layers below ground level (Broto (Broto, 2008).

Geo-electric method is one of the geophysical method to know the change of resistance of type of rock layers beneath the surface of the soil by passing a DC (Direct Current) that has high voltage in the soil. This electrical injection uses 2 (A and B) current electrodes that are plugged into the ground at a certain distance. The flow of electric current it will cause electrical voltage in the ground. Electrical voltage occurring at ground level is measured by using a multimeter connected through two electrodes of voltage M and N that are shorter than the electrode distance AB (Broto, 2008). The magnitude of resistivity is measured by passing an electric current into the earth and treating the rock layers as a conductor medium. Each material or rock has a different resistivity range than other materials (Adhi, 2007).

The geo-electric method often used in Indonesia has been so far confined to the Schlumberger and Wenner configuration. Both of these configurations are used in less-difficult fieldwork (quite flat and broad), and less penetration. In the geo-electric resistivity method for deep penetration, these two configurations become very weak, since they require a long stretch of straight electrodes, requiring good field conditions (uniform) and long-range change demands. To overcome the disadvantages of both configurations, dipole-dipole configurations are used which in principle has an executive advantage that can close some of the schlumberger and wenner configuration flaws, especially the need for cabling and time for relatively short spacing changes (Hendrajaya & Arif, 1990). So, the electrode configuration used in this research is dipole-dipole configuration.

2. Method

Geoelectric data was collected at the end of March 2017. Research location in Karst area of Temurejo Village, Karangrayung Sub-district, Grobogan District. With the design of the research location as shown at figure 1.
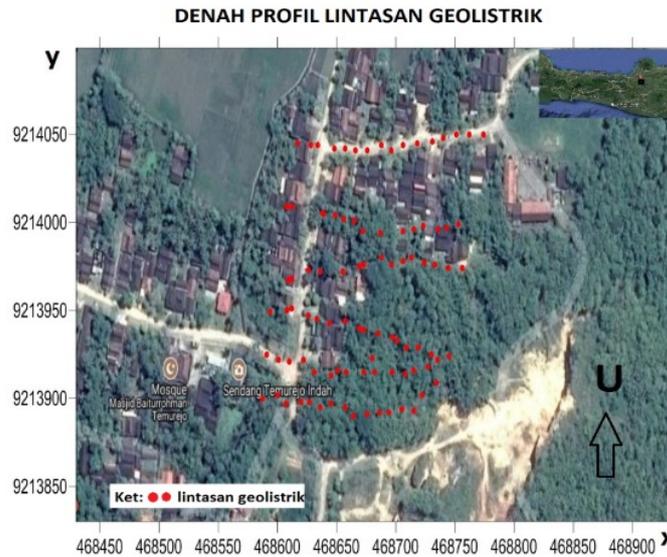
Figure 1. Geolistrik Track Design

Tools that used in the field in this research are: resistivitymeter type S-field Multichannel, two batteries with 12 volt voltage, 16 pieces of electrodes and connecting cables, and hammer secukupnya, global Positioning System (GPS) Garmin type 60CSx, Compass to determine the direction tracks, laptops / notebooks to record the measurement results, the meter to determine the location and distance between the electrodes, Software Ms. Excel, Res2dInv and Voxler 4

In the field data retrieval is done by using Multichannel geoelectric (S-Field) dipole-dipole configuration with 150 meters of track length and spacing of each electrode is 10 meters. The first stage of data acquisition is determine the center of the research track. Then, spread each 75 meter long cable to the right and left side of the center point of the track, then plug the electrode as much as 16 pieces and connect each electrode to a different cable. Lastly, do control of geoelectric data acquisition using geores acquisition software contained in PC.

Data of data acquisition result only consist of data of voltage value, current value, current electrode position and voltage electrode position. To get a apparent resistivity value, preliminary data needs to be processed using Microsoft excel and use the equation 1.

$$\rho_a = k \frac{\Delta V}{I}$$

$$(1)$$

with, ρ_a = apparent resistivity

k = geometry factor

ΔV = potential difference

I = current

Data processing results in Microsoft excel then saved with format .dat in notepad. After that the data is processed using Res2DInv software to get 2D cross-section.

3. Result and Discussion

Figs. 2 to 7 illustrate the subsurface through variations of rock type resistance values with the fifth iteration for each track. Sub-surface mapping model on track 1 to track 6 is created using Res2dinv software in the inverse modeling menu.

First Track

The first track is closest to the spring stretching from the northwest to the southeast direction. Results Interpretation on the first track can be seen in figure 2.
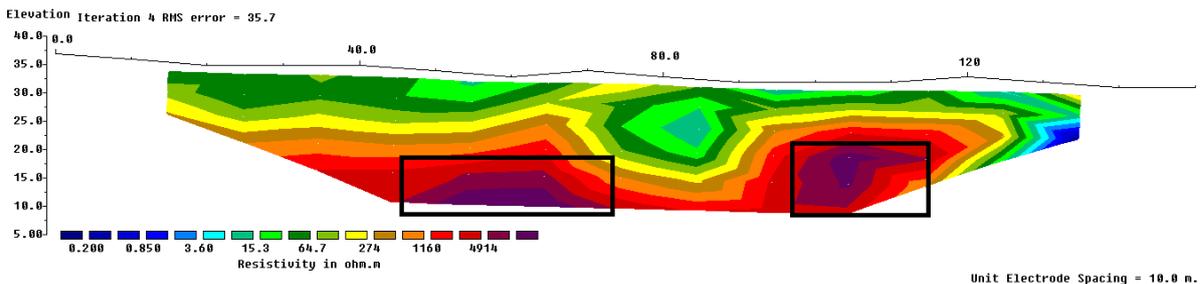

Figure 2. Cross-section Resistivity of Track 1

The results of the first track interpretation is this track consist of four layers of rock. The first layer has a resistivity value of 15.3-64.7 Ωm with a thickness of 5.35 m is a top soil layer in the form of sandclay. The second layer has a resistivity value of 64.7-274 Ωm is thought to be a carbonate sandclay layer with a thickness of 9.15 m. The third layer has a resistivity value of 274-1160 Ωm with a layer thickness of 3.8 m suspected to be a layer of carbonate sandstones. The fourth layer has a resistivity value of 1160-4914 Ωm at a depth of 18.3 m in allegedly comprising a well-qualified carbonate rock layer that has a large resistivity value. In this layer there are two anomalies of resistivity value that is more than 4914 Ωm. An anomaly is suspected as a cavity that contains air due to karstification process takes a very long time. The first cavity is at a depth of 20 m and a second cavity at a depth of 12 m. This wide air cavity has the potential to become an aquifer.

Second Track

The second track is ±25 m from the first track to the northeast direction. This track stretches from northwest to southeast direction with a width of 150 m. Results The 2D cross-sectional interpretation of the second track can be seen in Fig. 3.
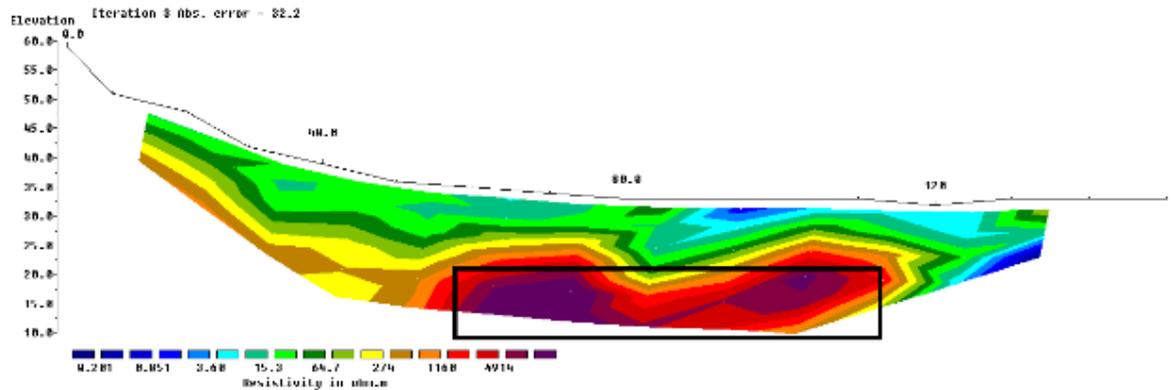
Figure 3. Cross-section Resistivity of Track 2

The second track interpretation result consists of four layers of rock. The first layer has a resistivity value of 15.3-64.7 Ωm with a thickness of 6.3 m is a top soil layer in the form of sandclay. The second layer with a thickness of 7.2 m has a resistivity value of 64.7-274 Ωm is thought to be a carbonate sandclay layer. The third layer has a resistivity value of 274-1160 Ωm with a layer thickness of 3.5 m suspected to be a layer of carbonate sandstones. The fourth layer has a resistivity value of 1160-4914 Ωm with a layer depth of more than 17 m in allegedly comprising a layer of carbonate stone which is well-justified so as to have a large resistivity value. In this layer there are still two anomalies of resistivity value that is more than 4914 Ωm that form a loop that is not perfect. The first cavity is shallower at the depth of 17 m while the second cavity remains at a depth of 12 m.
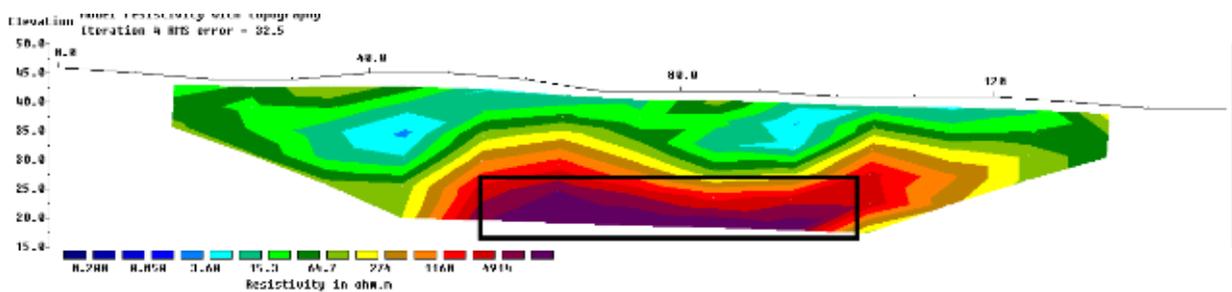
Third Track

Figure 4. Cross-section Resistivity of Track 3

The third track interpretation result consists of four layers of rock. The first layer has a resistivity value of 15.3-64.7 Ωm with a layer thickness of 12 m is a top soil layer in the form of sandclay. The second layer has a resistivity value of 64.7-274 Ωm with a layer thickness of 4 m alleged to be a carbonate sandclay layer. The third layer has a resistivity value of 274-1160 Ωm with a layer thickness of 3 m suspected to be a layer of carbonate sandstones. The fourth layer has a resistivity value of 1160-4914 Ωm with the thickness of the layer in the estimates consisting of a layer of carbonate stone which is well-justified so as to have a large resistivity value. In this layer anomaly resistivity value which is assumed cavity has been fused into a wide enough cavity that is ± 40 m at a depth of 17 m.
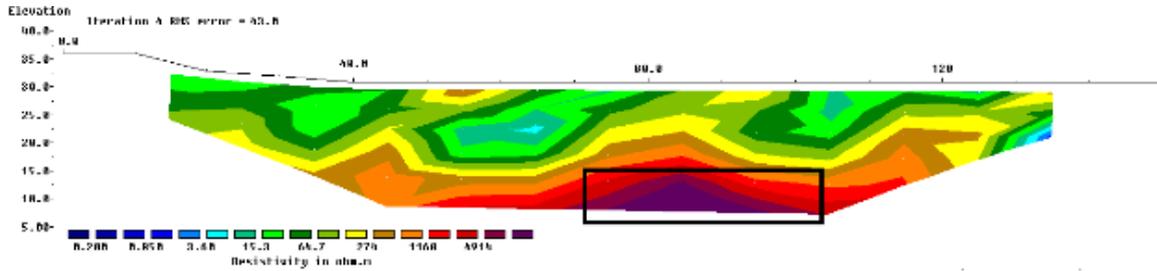
Fourth Track

Figure 5. Cross-section Resistivity of Track 4

The fourth track interpretation result consists of four layers of rock. The first layer has a resistivity value of 15.3-64.7 Ωm with a layer thickness of 2-16.3 m is a top soil layer in the form of sandclay. The second layer has a resistivity value of 64.7-274 Ωm with a layer thickness of 2-6 m alleged to be a carbonate sandclay layer. The third layer has a resistivity value of 274-1160 Ωm with a layer thickness of 2-4 m suspected to be a layer of carbonate sandstones. The fourth layer has a resistivity value of 1160-4914 Ωm with the thickness of the layer in the estimates consisting of a layer of carbonate stone which is well-justified so as to have a large resistivity value. In this layer anomaly resistivity value which is assumed cavity has been fused into a wide enough cavity that is ± 40 m at a depth of 18 m.
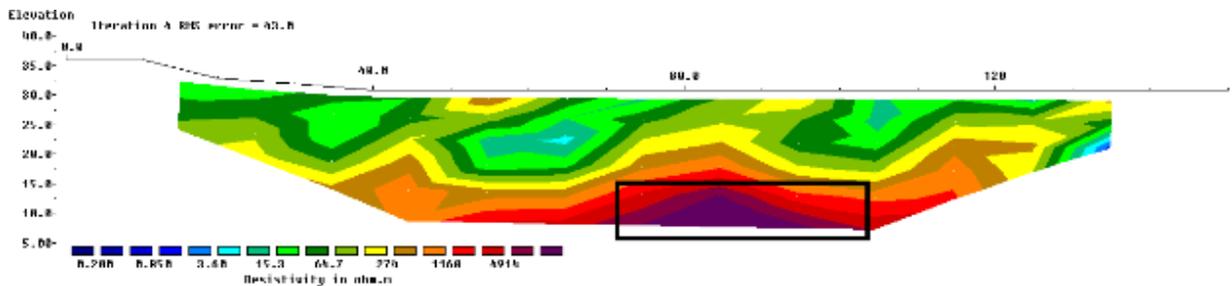
The Fifth Track

Figure 6. Cross-section Resistivity Track 5

The result of the fifth track interpretation consists of four layers of rock. The first layer has a resistivity value of 15.3-64.7 Ωm with a layer thickness of 5 m is a top soil layer in the form of sandclay. The second layer has a resistivity value of 64.7-274 Ωm alleged to be a carbonate coat layer with a layer thickness of 5 m. The third layer has a resistivity value of 274-1160 Ωm with a layer thickness of 2 m is the layer of carbonate sandstones. The fourth layer has a resistivity value of 1160-4914 Ωm located at a depth of 18 m in allegedly consisting of a layer of carbonate stone that is well-justified so as to have a large resistivity value. In this layer there is one resistivity value anomaly that is more than 4914 Ωm at a depth of 18.
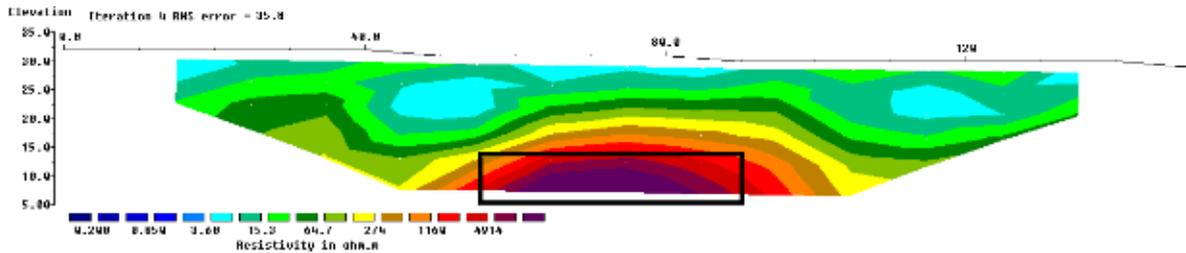
The Sixth Track

Figure 7. Cross-section Resistivity Track 6

The result of the sixth track interpretation consists of four layers of rock. The first layer has a resistivity value of 15.3-64.7 Ωm with a layer thickness of 8 m is a top soil layer in the form of sandclay. The second layer has a resistivity value of 64.7-274 Ωm alleged to be a carbonate coat layer with a layer thickness of 7 m. The third layer has a resistivity value of 274-1160 Ωm with a layer thickness of 2 m is layer of carbonate sandstones. The fourth layer has a resistivity value of 1160-4914 Ωm located at a depth of 18 m in allegedly consisting of a layer of carbonate rock that is well-justified so as to have a large resistivity value. In this layer there is one resistivity value anomaly that is more than 4914 Ωm at a depth of 18.

In Figure 2 to Figure 7 shows the subsurface for track 1 to track 6 where the lowest resistivity value of rock is 0.2 Ωm (dark blue) and the highest resistivity value is more than 4914 Ωm (purple color). The dominant rocks in each layer of this study were carbonate rocks indicated by a resistivity value of >64 Ωm in accordance with Table 1 ie the range of carbonate rock resistivity value reached 50-10^7 Ωm. The 2D image results as shown in the figure above show the lithology of rocks and cavities that have the potential to be underground rivers. An anomalous rock resistivity value indicating the cavity is the highest resistivity value because the cavity contains air (>4914 Ωm).

There are two air cavities in the first track which then begin to converge on the second track. The cavities are respectively at a depth of 20 m and 12 m. Then on the second track the wider cavity rises at a depth of 17 m while the second cavity remains at a depth of 12 m. On the third track seen the two cavities have been fused into an elongated cavity of ± 40 m with a depth of 18 m. Furthermore the cavity remains at a depth of 18 m on track 4, 5, and 6.

4. Conclusion

From the results of data processing resistivity nila into 2D cross-section and 3D cross-section can be concluded that:
1. The lithology of the research area is composed of layers of sandclay, carbonate sandclay rock, carbonate sandstone, and carbonate rock.
2. The cavities system is thought to be at a depth of 12-18 m.

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