IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 6, Issue 6 Ver. I (Nov. – Dec. 2018), PP 77-81
www.iosrjournals.org

3D Modeling of Resistivity Methods on Iron and Concrete Anomaly Using Dipole-Dipole Configuration

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Abstract: *Laboratory modeling studies using the resistivity method have been carried out to determine the location of anomalies in the form of iron and concrete which are placed in the soil at predetermined coordinates. In this study it was buried in sub surface cylinder iron anomaly, iron sheet anomaly and concrete anomaly. Dipole-dipole configuration resistivity method is used to determine the location of anomalies based on the resistivity of an anomaly in the form of iron and concrete. Retrieval of data with Dipole-dipole configuration is done by taking 21 tracks. Tracks 1-7 stretch length 13 meters and tracks 8-21 long stretch 6 meters. Trails 8-21 intersect with paths 1-7. The distance of the electrode used is 1 meter. Pseudo resistivity data is then inverted using Res3dinv64x software. The results of inversions give resistivity values varying from 4.8 Ω̣mto 89.1Ω̣m. In this study iron anomalies give resistivity values of 11Ω̣m with an error in determining the location of ± 16%, while the concrete gives a resistivity value of 16.7 Ω̣mwith an error in determining the location of ±20%*
Keywords:*3D modeling, resistivity method, Dipole-dipole configuration.*

Date of Submission: 06-10-2018 Date of acceptance: 10-12-2018

I. Introduction

The resistivity method is one of the geophysical methods that utilizes the nature of electricity as a means to recognize conditions under the earth's surface based on the contrast value of its resistivity [1]. Resistivity is one of the physical properties possessed by rocks, namely the ability to pass electric current. If rocks are increasingly difficult to pass by electric current, the greater the amount of resistance given by these rocks is also greater [2]. The resistivity method is one of the methods used in shallow exploration. The aim is to find out the subsurface structure by taking measurements at ground level. Measurements are made by injecting current into the ground through the current electrode and measuring the potential difference produced at two potential electrodes with a specific configuration. The resistivity method is usually used to estimate subsurface rock resistivity, search for water reservoirs, and geothermal exploration. This method can also be used to identify mineral seeds. The resistivity method is commonly used to search for targets that have contrast resistivity with their environment [3]. Rock resistivity is related to various geological parameters such as the presence of minerals and fluid content, porosity, degree of faults, percentage of faults filled with groundwater and the degree of water saturation in rocks [4].

The resistivity values of rock and mineral types are grouped into three, namely good conductors, medium conductors and insulators [5].The resistivity method can be carried out in 3D so that it is able to provide a more detailed picture of the surface about detention. This is because not only provides the image of the type of resistivity distribution in the vertical cross section but also the horizontal cross section [6]. In this study the dipole-dipole configuration was chosen because of several advantages over other configurations in providing subsurface images. This configuration can also describe subsurface objects that are relatively deeper compared to other configurations. Another advantage of the dipole-dipole configuration is the low electromagnetic effect generated between current and potential circuits [7].

The resistivity method is a method that studies the physical properties of rocks when an electric current is injected on the earth's surface and measures its potential difference [8]. The principle of the type resistance method is by injecting the subsurface current through the current electrode, then the potential electrode will be a medium to measure the potential difference that occurs. From the results of current measurements and potential differences with certain electrode configurations, we can determine the variation in resistivity values of each layer below the measurement point [9].

The 3D type of resistance method is able to provide a better picture of the earth's subsurface when compared to the 2D type resistance method [10]. The 3D method can provide a vertical or horizontal description of the subsurface [6]. The 3D type of detention method is rarely used in geophysical surveys, this method is a development of the type resistivity method itself.

3D type resistivity methods typically use Pole-pole, Pole-dipole, and Dipole-dipole configurations. The reason is because other configurations have less data coverage near the edge of the survey grid. In some surveys, 3D data is a combination of several paths from parallel 2D methods. Although there should be data on the x-axis path that intersects the y axis. The measurement of the two axis directions can reduce the slope of the direction in the data, so it is necessary to have a survey that forms a grid [11] as shown in Figure 1.

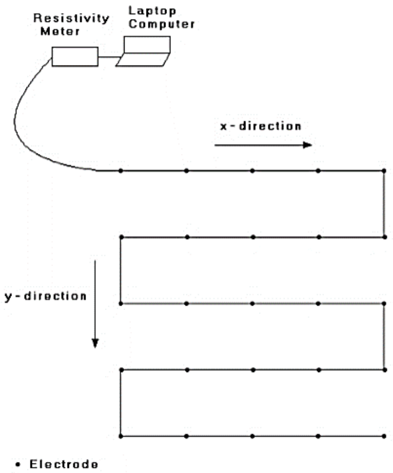

Figure 1 Preparation of grid electrodes for 3-dimensional survey[11].

The advantage of the Dipole-dipole configuration compared to other configurations is the low electromagnetic effect generated between current and potential circuits. In addition the penetration is relatively deep compared to other mapping methods such as Schlumberger and Wenner configurations so that by using a dipole-dipole configuration it can get the image of the subsurface with a deeper depth [7].

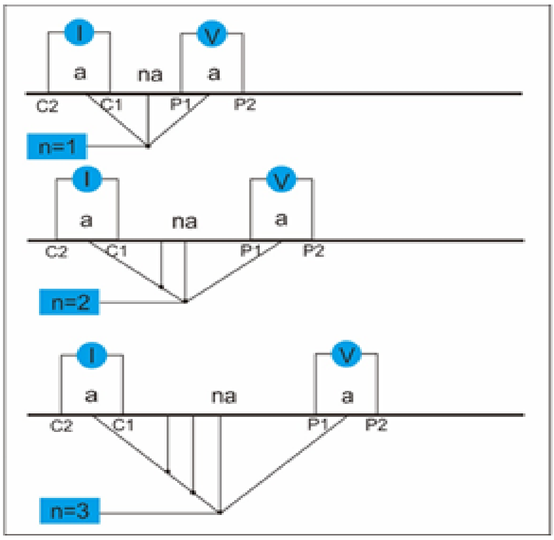

Figure 2 Dipole-Dipole Configuration[12]

Figure 2 shows that the Dipole-dipole configuration electrode array is arranged in the order C2-C1-P1-P2. The C2-C1 current electrode pair and the potential electrode pair P1-P2 are separated by the distance "a". There is another amount in this arrangement, namely "n". This is a comparison between the two current or potential electrode pairs. Each electrode configuration in the type resistance method has a sensitivity price that describes the accuracy of the measured data and is related to the "n" factor used [5].

The price of the greatest sensitivity is generally located between the pair of current electrodes and potential electrode pairs. This shows that this arrangement is very sensitive to changes in resistivity under the electrode at each pair. As the "n" factor increases, the high sensitivity value is increasingly concentrated below the current and potential electrode pairs, while the sensitivity value under the electrode of the deepest potential current is getting smaller [13]. Each configuration has a K value which is a geometry factor of the electrode arrangement. Each electrode configuration has different geometry factors. The geometry factor of the Dipole-dipole configuration can be written with equation (1) [5,7].

$$K = \pi an(n+1)(n+2) \quad (1)$$

Quasi-type resistivity values for Dipole-dipole configurations can be written with equation (2) [5,7]:

$$\rho_a = \pi an(n+1)(n+2)\frac{\Delta V}{I} \quad (2)$$

II. Research Methods

The research was conducted by buried iron anomaly models in the form of sheets with a size of 40 cm x 40 cm 2 cm thick and in the form of cylinders with a diameter of 40 cm and 50 cm long, as well as concrete (a mixture of sand and cement) with a size of 40 x 40 cm with a thickness of 20 cm planted in the specified coordinates. The research data was taken on April 15 - May 5, 2018 by making an acquisition on the front page of the Advanced Laboratory of the Physics Department (Our Home Garden), Faculty of Science and Mathematics, Diponegoro University. Iron anomalies are buried with a distance of 2 meters and a concrete buried at 2 meters of iron and the last concrete is planted at a distance of 3 meters as shown in Figure 3. The iron plate anomalies is located at coordinates (3 m, 3 m) with a top edge depth of 0, 5 m. While the iron cylinder anomaly is located at coordinates (3 m, 5 m) with a depth of 0.75 meters. For anomalies in the form of 2 concrete pieces planted at coordinates (3 m, 7 m) and (3 m, 10 m) with the same depth of 1 meter. The acquisition was carried out using a dipole-dipole configuration of 21 tracks, with 7 stretches of 13 meters and 14 tracks with a stretch of 6 meters which cut lanes 1-7. The distance of the electrode used is 1 meter with n 1,2,3,4,5. The acquisition results will be processed with Ms. software. Excel 2013 and Res3dinv64x to get a 3D cross section that is against the X-Y, X-Z and Y-Z axes and using Rockworks 15 software to create a solid 3D model.

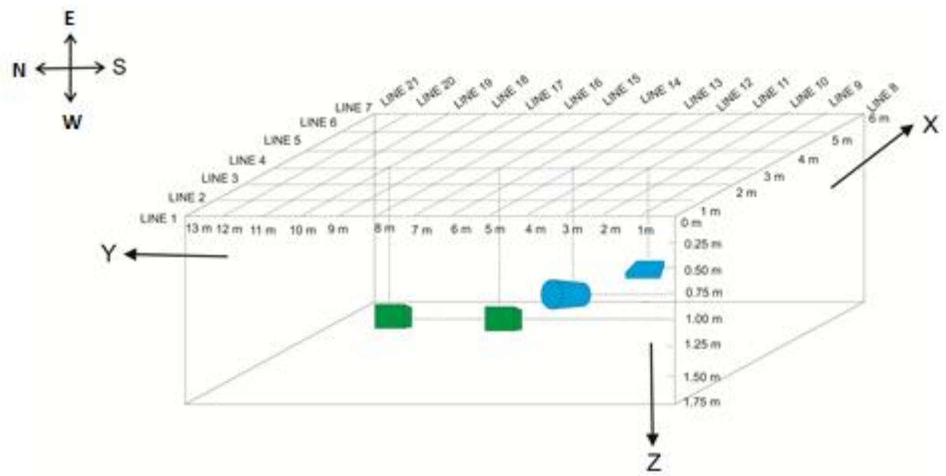

Figure 3 Model scale survey design

Coordinate data C1, C2, P1 and P2 on the x-axis and y-axis and apparent resistivity were obtained during the acquisition in the field. The data then becomes the input of the Res3dinv64x software so that the inversion process is carried out and get an output in the form of a subsurface section that can be displayed horizontally or vertically. Horizontal cross section of x-y can be arranged vertically with Corel Draw software, while vertical cross section of x-z and y-z can be arranged horizontally. Arrangement of cross sections to facilitate interpretation and compare with actual models.

III. Results And Discussion

The results of 3D inversion in the horizontal direction (x,y) are shown in Figure 4. Whereas and in the vertical direction (x,z) shown in Figure 5 and the vertical cross section (y,z) is shown in Figure 6. The resistivity values vary between 4.9 -144, 9. The horizontal cross section of the x-y axis arranged vertically with Corel Draw gives a 4-layer cross section of the subsurface. Vertical cross sections can be shown on the x-z axis as shown in Figure 5 and the vertical cross section of the y-z as shown in Figure 5. Figure 5 provides a vertical cross section with 13 subsurface resistivity profiles, while the vertical cross section of the y-z axis shown in Figure 6 shows 6 resistivity profiles.

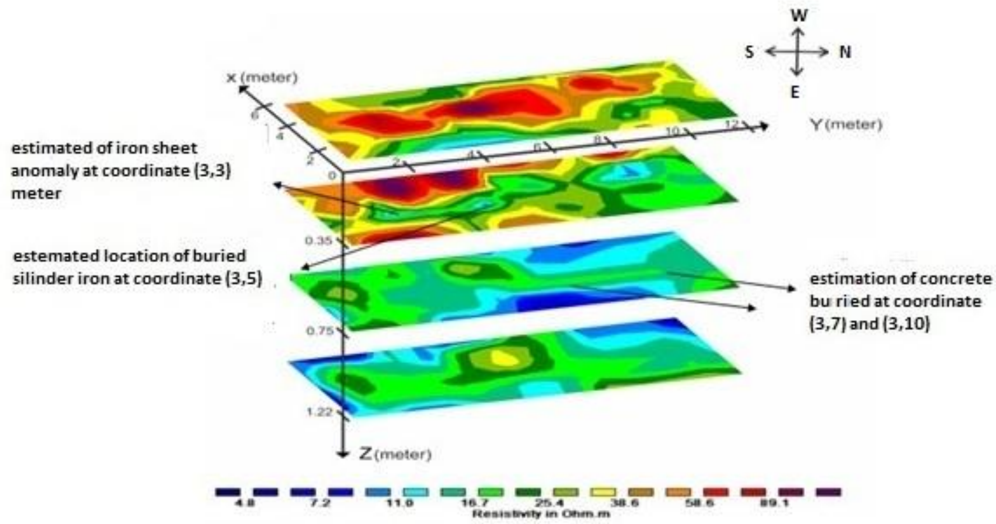

Figure 4 Horizontal cross section (x-y) arranged vertically

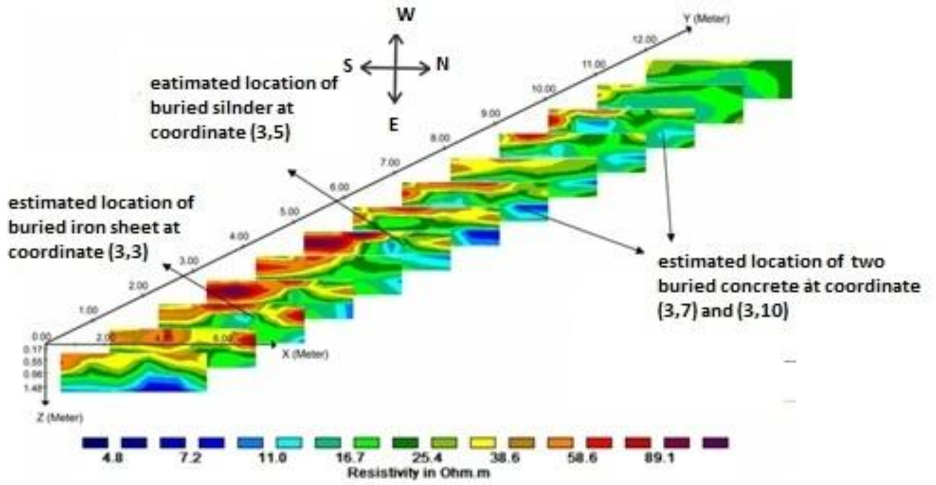

Figure 5 Vertical cross section (x-z) arranged horizontally

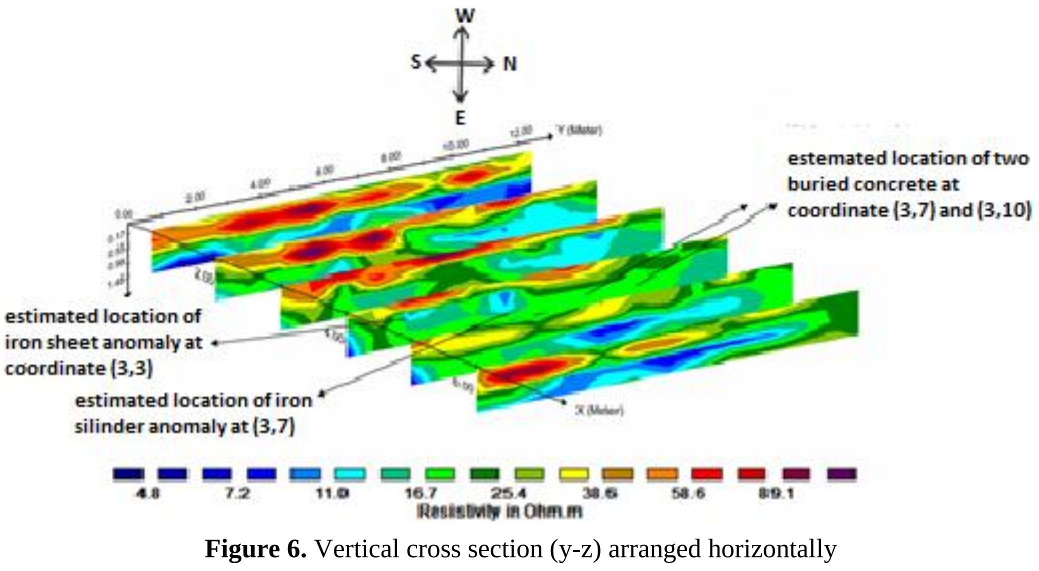

Figure 6. Vertical cross section (y-z) arranged horizontally

Figure 4 shows that the second layer with a depth of 0.35-0.75 meters is the position of the iron plate anomaly and the cylindrical iron is planted at coordinates (3,3) and (3,5) is the iron resistivity that has contact with the clay so that it has resistivity 11 which is imaged by light blue. While the third layer with a depth of 0.75 - 1.22 meters is the position of two concrete anomalies. At the coordinate point (3.7) and (3.10) the concrete resistivity is indicated by a resistivity value of 16.7.

For the vertical cross section of the x axis shown in Figure 6, the third profile located on the 2nd and 3rd trajectory has a low resistivity value on the 3rd track at a depth of 0.5 meters which is the resistivity of the iron plate that has been in contact with the soil layer. Whereas the sixth profile on the path to 5-6 also has low resistivity. At a depth of 0.75 meters in accordance with the depth of the iron cylinder imaged with light blue with a resistivity value of 11 is iron resistivity which is contacted with the surrounding soil layer. For both concrete located at the coordinate point (3.7) and (3.10) there is no apparent high resistivity imaged in purplish red. The resistivity of concrete is only illustrated with a tapered pattern with a resistivity value that is not much different from the surrounding conditions.

The fourth profile which is on line 3-4 is a path where the four anomalies are planted in a row shown in Figure 6. The third track at a depth of 0.5 meters has a low resistivity of 11. On the 5th track at a depth of 0.75 meters it also has a low resistivity which is worth 11. Low resistivity is the resistivity of iron plates and iron cylinders, if correlated with vertical x-z cross section and horizontal cross section, it can be interpreted that iron resistivity has been in contact with the soil layer so that it provides low resistivity imaged in light blue.

Anomalies in the form of concrete when correlated with vertical x-z cross section and horizontal cross section, the resistivity does not image with purplish red with high resistivity, but only forms a pattern. If the horizontal cross section of the pattern is straight to North with a resistivity value of 16.7 between the low resistivity blue, then the vertical cross section x-z is depicted with a tapered down pattern at each concrete coordinate planted. The vertical cross section of the y-z pattern is a straight pattern which, when viewed by other layers, shows that this fourth layer has a resistivity of 16.7 in the north, while the other layer has a resistivity of 4.8 to 11 in its northern part. The existence of concrete can be said to provide higher resistivity than the surrounding resistivity. The Dipole-dipole configuration cannot clearly image anomaly in the form of concrete.

IV. Conclusion

From this research can be concluded that the 3D resistivity method with dipole-dipole configuration can be used to determine the location of anomalies in the form of iron sheet, iron cylinders and concrete. The iron plate anomaly is located at coordinates (3 m, 3 m) at a depth of 0.35 to 0.75 m and a resistivity value of 11Ωm, iron cylinders located at coordinates (3 m, 5 m) at a depth of 0.75 - 1.22 m with ± 16% error. The Anomaly in the form of 2 concrete pieces located at coordinates (3,7) and (3,10) at a depth of 0.75 - 1.22 meters with a resistivity value of 16.7 Ωmwith an error of ± 20%.

Acknowledgements

The author would like to thank the head of the Geophysics laboratory for motivation and the use of resistivity meter devices and the head of the Department of Physics who have lent the garden of Physics laboratory building as a means of modeling.

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