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Comparison Of Several Configurations On Geolistrical Methods In Determining Site's Anomaly

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Abstract- Research on the accuracy of configuration's anomaly estimation on the geoelectric method has been done. An anomalous cast concrete model (mixture of cement and sand without iron frame) with diameter 30 cm and length 50 m which is planted at depth 50 cm from the surface. After being planted for a while, the measurement of the pseudo-type resistance through the anomaly site with various methods which then is performed data processing and inversion with RES2DIVN software. The configurations compared are Wenner configuration, dipole-dipole configuration, and Wenner Schlumberger configuration. The most accurate tested configuration to determining the anomaly is the wenner configuration.
Keyword : Geoelectric, Configuration, anomaly, RES2DIVN

I. INTRODUCTION

The most common method used in geophysical exploration is geoelectric resitivity method. The resistivity method utilizes an electrical resistivity of rocks to detecting and mapping the rock condition beneath the surface. The method's basic principle is measuring the potential difference as a result of injected electrical current into the earth with a particular configuration. The magnitude of the injected current and the measured potential difference is reflected the rock condition beneath the earth surface based on its resistivity properties. The electrical properties of a rock formation can be illustrated by three basic parameters: electrical conductivity, magnetic permeability, and dielectric permittivity (Williams,1986).

The previous researchers are proposed several configurations regarding geoelectric resistivity method of injecting currents and measuring the potential difference. Those configurations include Wenner's configuration, Half Wenner configuration, Schlumberger configuration, Half Schlumberger configuration, Dipole-dipole configuration, and Mase-a-lamase configuration (Telford, et al 1990). Each configurations has its own composition on injecting current and measuring potency differentials, which definitely provide distinctive anomaly site's prediction. Therefore, this study will be compared each configurations (mentioned above) include its accuracy in detecting the anomaly site (concrete cast) on semi-field scale (the laboratory yard).

This study is comparing the accuracy between two dimensional resistivity methods of Wenner, Wenner-Schlumberger and dipole-diploe configurations in estimating the anomalous object's site based on its resitivity. The result is expected to decide a proper configuration on the field, in addition it can be used as a reference for researchers who conducted similar research as well as in geoelectric resitivity research's development.

II. THEORY

Geoelectric is one of the geophysical methods to determining the resistance (resistivity) changes' variation of rock layers beneath the earth's surface by injecting the high-voltage DC current into the ground. Injecting an electric current is carried out by using four electrodes which are plugged in a predetermined distance. Two electrodes as current electrode and others as potential electrodes. The longer its sparse the longer the layer of rock which can be measured (Broto, 2008).

One method used in geophysical exploration is resistance method. Geoelectric resistance utilizes the electrical resistivity of rock's characteristics to detecting and mapping the subsurface formation. This method is held by measuring the potential difference of electrical current's injection into the earth. The measurable potential difference reflects the state beneath the earth's surface. The properties of its formation can be illustrated by three basic parameters: electrical conductivity, magnetic permeability, and dielectric permittivity (Williams,1986).

The measurement interpretation is based on the assumption that the surface consists a number of different layers of resistance. Each layer is formed by a horizontal boundary and is an isotropic homogeneous medium. To determine the resistance and the boundary depth based on the result of potential difference and the spacing distance of each electrode, thus the mathematical relation between the measured parameters and the defining parameters for subsurface layer distribution (Telford, 1990).

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As for dipole-dipole configuration, the distance between the pairs of current electrodes is "a" which is equal to the distance of a pair of potential electrodes as illustrated in Fig. 1. There is another quantity in this arrangement which is "n". This is the distance between the pair of current or potential electrodes. The magnitude of "a" is fixed and the "n" factor increases from 1 to 2 to 3 up to 6 to increasing the depth of investigation.

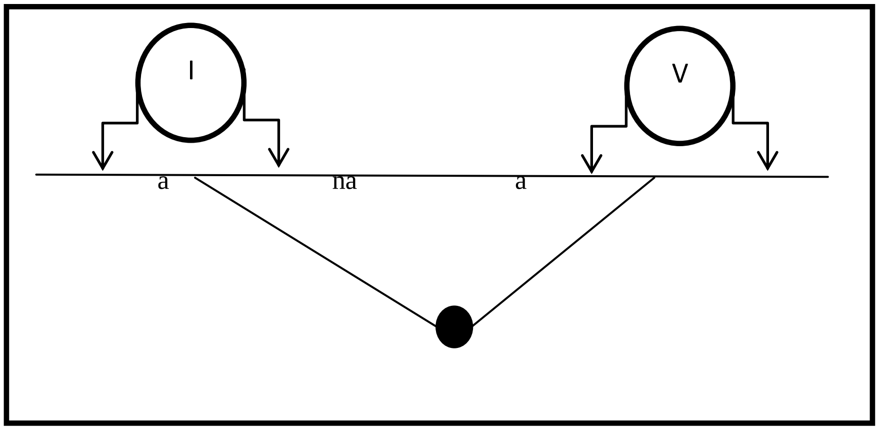

Figure 1 Dipole-Dipole Configuration (Loke,2004)

Each electrode arrangement has a sensitivity value that indicates the data's accuracy of with the value of factor "n". Figure 2 shows that the sensitivity of this arrangement for "n" from 1 to 6 called 2 dimensional resistance measurement.

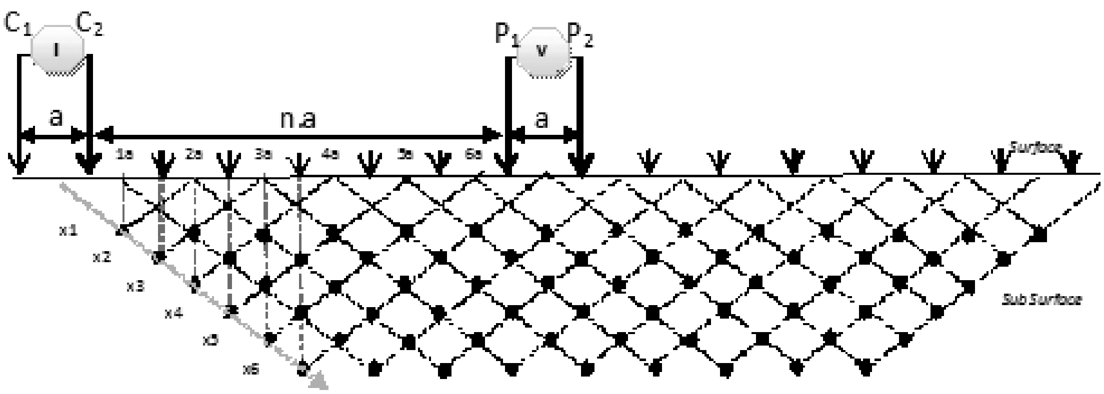

Figure 2 The n variation against the depth of investigation (Loke.2004)

For the apparent resistivity is described according to the formula below,

$$\rho_a = \frac{V}{I}\pi a(n+1)(n+2) \tag{2.1}$$

as ρ is the apparent resistivity within Ωm, *a* is the spacing electrode (distance between electrode C1 and P1) within m, *R* is the direct measured resistivity within Ω. From the equation above πa is the geometric factor (Faqih, 2009). The configuration arrangement of schlumberger can be seen in Figure 3.

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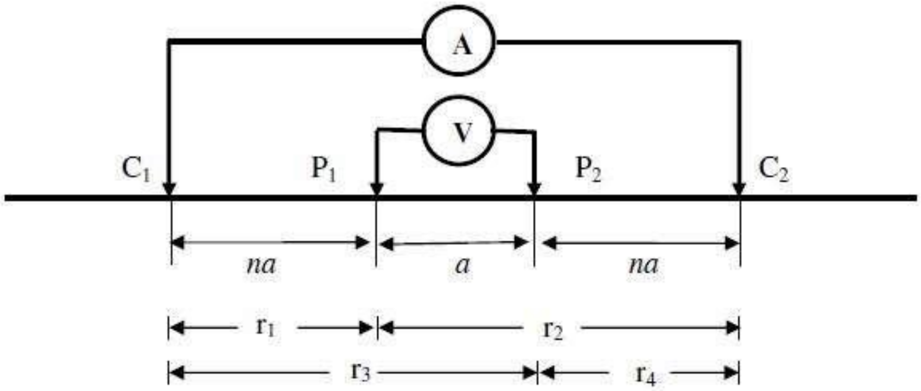


Figure 3 The Schlumberger Configuration (Telford, 1990).

As Figure 3 explained, the electrodes P1 and P2 are potential electrodes while the C1 and C2 electrodes are current electrodes. “a” is the distance between the potential electrode where the distance “a” is fixed and the distance between the current and the potential electrode (P -C1 or P2-C2) is changed by “n” times “a” where the distance “n” is the number 1,2,3, ... etc. According to (Rahmah, 2009) the maximum length of “na” must be at least 3-5 times maximum of the investigative depth and the AB / MN ratio is 2.5 <AB / MN <50. In the Schlumberger configuration, the apparent resistivity equation can be expressed in equation 2.2.

$$\rho_a = \pi \left[\frac{b^2}{a} - \frac{a}{4}\right]\frac{V}{I} = K\frac{V}{I} \quad (2.2)$$

With K is the geometric factor, ρ_a is the value of the rock resistance, V is the potential difference, *I* is current, *b* is the distance of current electrode, *a* is the distance of potential electrode (Broto, 2008).

The electrode’s arrangement in Wenner configuration can be seen in Figure 4.

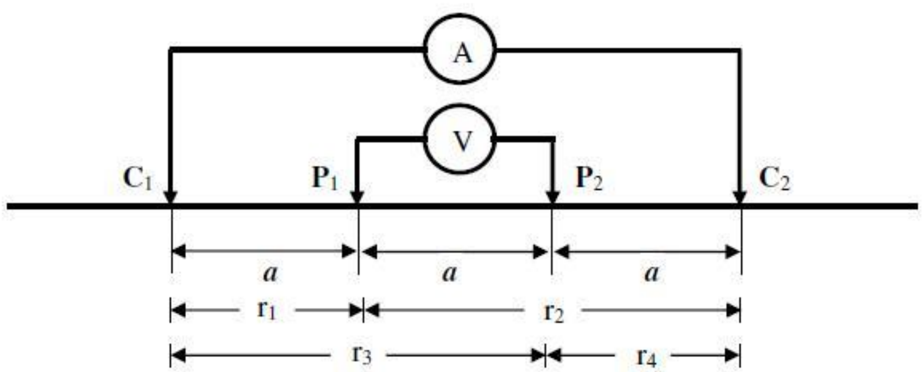


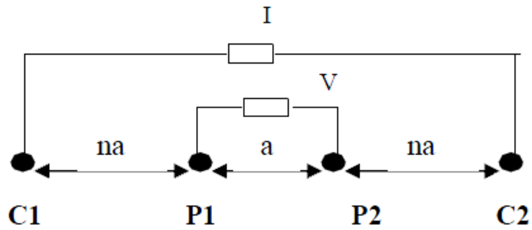
Figure 4 Wenner Configuration (Rahmah, 2009, Reynold, 1997)

After the wenner configuration’s measurement, thus the parameters will be obtained in the form of current (I), potential difference (V), distance between station and electrodes (AB / 2 and MN / 2). From these parameters, the geometry factor and the value of resistance can be calculated according to the following equation 2.3 (Reynold, 1997):

$$\rho_a = 2\pi a \left(\frac{\Delta V}{I}\right) = K\frac{\Delta V}{I} \quad (2.3)$$

As K is the geometric factor, ρ_a is the value of the rock resistance, V is the potential difference, *I* is current, *a* is the distance of electrode (Rahmah, 2009).

The distance of Wenner-Schlumberger configuration between potential electrode (P1 and P2) is "a" then the distance between the current electrode (C1 and C2) is 2na + a. The resistivity determination process utilized 4 electrodes placed in a straight line as shown in Figure. 5. (Sakka, 2001).



$$k = \pi n(n+1)a$$

Figure 5. The Wenner-Schlumberger configuration's arrangement (Telford, et al 1990)

The apparent resistivity equation in the Wenner-Schlumberger configuration can be expressed in the following 2.4: (Telford, et al 1990)

$$\rho_a = \pi n(n+1)a\frac{\Delta V}{I} \quad (2.4)$$

III. THE METHOD OF RESEARCH

In the preparation stage, the anomaly model is made of two concrete casts without iron which then planted about 0.5 m within the earth and separated at a distance of 0.5 m and the coordinate is specified in the Geothermal FSM building's yard.

Field data measurement was performed using *Resistyvity* meter using dipole-dipole, Schlumberger and Wenner configuration. In this configuration, four electrodes are used which two of them are used as current electrodes and the other two as potential electrodes. Then the four electrodes are connected with *Resistivity meter* (NANIURA) using the cable according to the configuration above. In this study, the electric power which supply the resistivity meter is GGL DC 12 V from dry ACCU.

The field data are processed using RES2DIVN software in order to obtaining the 2D surface model. The first step in the geoelectric data process is inputing the physical field data in Microsoft Excel format. The measured numbers are potential (V), current (I), distance between electrodes (a), electrode separator factor (n), geometric factor (K), resistance (R), apparent resistivity (ρ_a), and datum point. Then electrode data (a), electrode separator factor (n) and datum point are inputted into the notepad software program and made into a text file format .dat. Thus the file can be inputed to the RES2DIVN software and processed which later it will be obtained an inversion model to display the subterranean cross section image.

The 2 Dimensional data as an output from the RES2DIVN's processing will be displayed in the form of vertical and horizontal cross section. Then the three dipole-dipole, the schlumberger and wenner configuration's cross sections each can be analyzed the different responses to objects planted beneath the earth's surface.

IV. RESULT AND DISCUSSION

The measurement result and resistivity inversion of the two-dimensional's Wenner configuration is shown in Figure 6. From the figure, the Wenner configuration looks very sensitive to local inhomogeneity, the two anomalous objects can be seen clearly (circled).

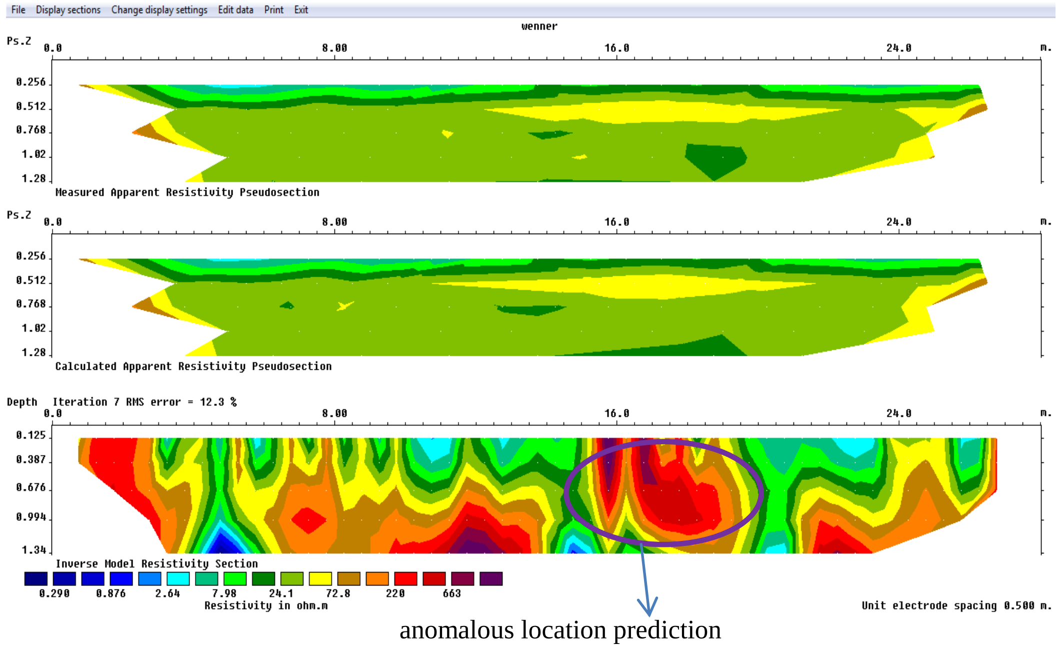


Figure 6 The Wenner Configuration's 2D Resistivity Modeling Result

The measurement result and resistivity inversion of the two-dimensional's Wenner configuration is shown in Figure 7. From the Figure 7, the Wenner configuration looks insensitive to local inhomogeneity, the anomalous site is circled.

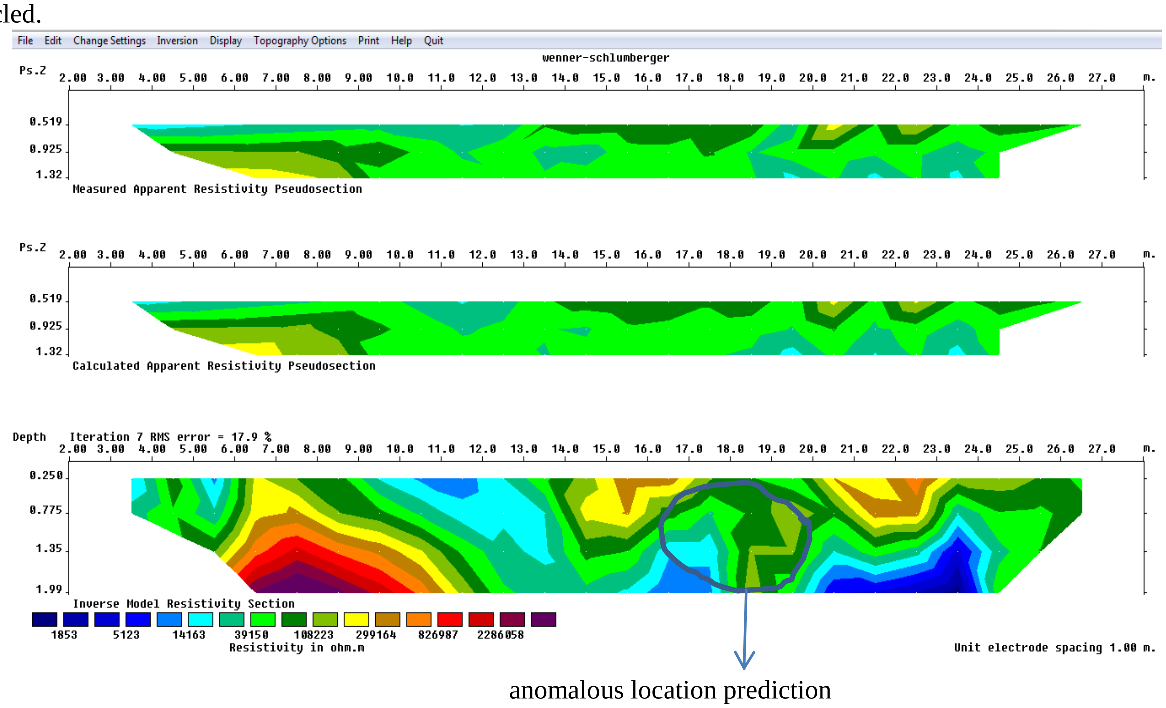


Figure 7 The Wenner-Schlumberger Configuration's 2D Resistivity Modeling Result

The Dipole-dipole Configuration's 2D Resistivity Modeling Result is shown in Figure 8. The dipole-dipole configuration looks insensitive to inhomogeneity, the anomalous site is circled.

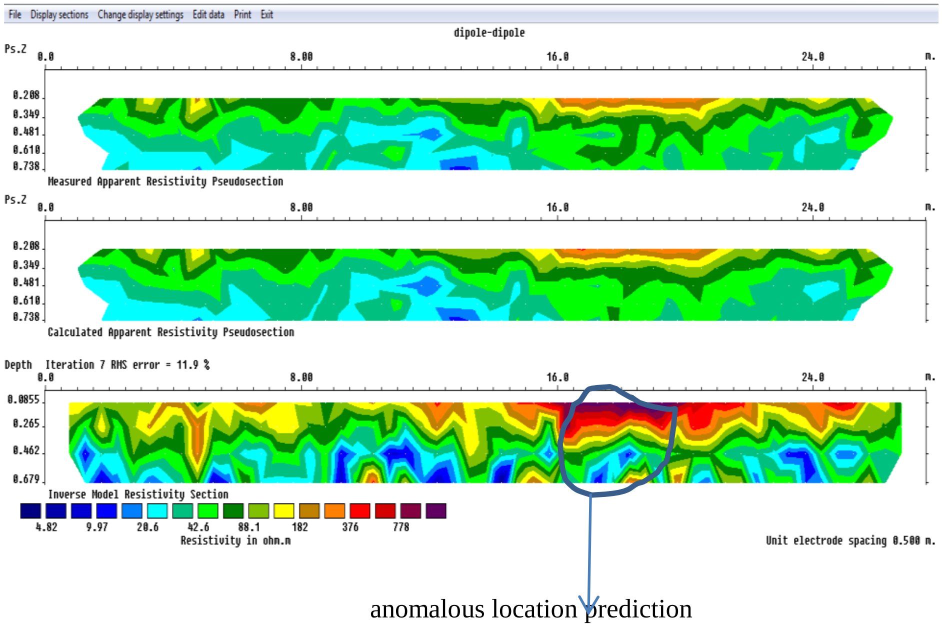


Figure 8. The Dipole-dipole Configuration's 2D Resistivity Modeling Result

The modeling results show that the Wenner configuration is most sensitive in detecting anomalous object beneath the earth which shown the its capability to detecting two separate anomalous objects at distance of 0.5 m, whereas the other two configurations (Wenner-Schlumberger and Dipole-dipole) couldn't show the separate modeling results of two objects at relatively close distance.

The Wenner and Dipole-dipole configurations have similar resemblance regarding the modeling results which both methods are showing detect local homogeneity, whereas the Wenner-Schlumberger configuration is relatively not suitable for surface-based surface modeling. The Wenner-Schlurger method is capable of penetrating deeper to detecting the anomalous objects beneath the surface, in this study it was able to penetrate twice than the Wenner and Dipole-dipole configuration.

V. CONCLUSION

The result of this study shows that Wenner's two-dimensional resistivity method is reflecting the resitivity of anomaly situation better than the Wenner-Schlumberger and Dipole-dipole configurations. This result is assumed due to the current and potential electrode in the Wenner configuration is always changing and the greater distance of potential electrode.

VI. ACKNOWLEDGMENT

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