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Abstract:

The main purpose of this report is to apply the resistivity method, along the Astara Fault in Gisum area, Gilan province. In order to detect the fault trace, three Dipole- Dipole, Pole- Dipole arrays with 10 m interval for each station, and Wenner array with 2.5 to 30 m interval measured. Totally three Dipole- Dipole arrays studied, and along profile one, two more arrays (Wenner and Pole-Dipole) also surveyed. As a whole, 116 stations measured with RS method.

The RS method carried out in the vicinity of Gisum road. In order to detect the fault trace, three Dipole- Dipole arrays (with 10 m interval for each station) and pole- dipole array (with 2.5 to 30 m interval for each station) measured.

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Geological Investigation (RS method) along the Astara Fault

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Geological Investigation

(RS method) along the Astara Fault

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Geological Investigation (RS method) along the Astara Fault

Author: Seyyed AbolHasan Razavi

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1- INTRODUCTION

The main purpose of this report is to apply the resistivity method, along the Astara Fault in Gisum area, Gilan province (Figure 1 & Figure 2). In order to detect the fault trace, three Dipole- Dipole, Pole- Dipole arrays with 10 m interval for each station, and Wenner array with 2.5 to 30 m interval measured. Totally three Dipole-Dipole arrays studied, and along profile one, two more arrays (Wenner and Pole- Dipole) also surveyed. As a whole, 116 stations measured with RS method.

2- RESISTIVITY / METHOD

The RS method carried out in the vicinity of Gisum road (Figure 1). In order to detect the fault trace, three Dipole- Dipole arrays (with 10 m interval for each stations) and pole- dipole array (with 2.5 to 30 m interval for each stations) measured.

Figure 1: Geographical location and access ways of the studied area.

In this survey, the artificial electric currents with two electrode injected to the earth and potential different resulted from two points measured in the surface of the ground. In this respect, the deviation from the expected different potentials in the homogenous zones, produce some information's about the form and electrical characteristics of the subsurface inhomogeneity. Resistivity is one of the physical properties of rocks. Some minerals such as metallic and graphite can conduct the electrical currents but most of the rock minerals are impermeable and electrical currents mostly transferred through water ion and pores. Therefore, most of rocks transfer electricity by way of electrolyte rather than electronic. This means that porosity is the most rock resistivity controller, and water content of the porous, and water electricity of water have important role and can change the resistivity of rocks. Therefore, there is a great overlap between the electrical resistivity of rocks. So, recognition of rocks, only based on resistivity is impossible. For electrical resistivity measurement, the straight electrical currents will be send by two electrode currents (A, B) to interior of the earth, then potential different between two electrodes potential (M, N) will be measured on the ground surface.

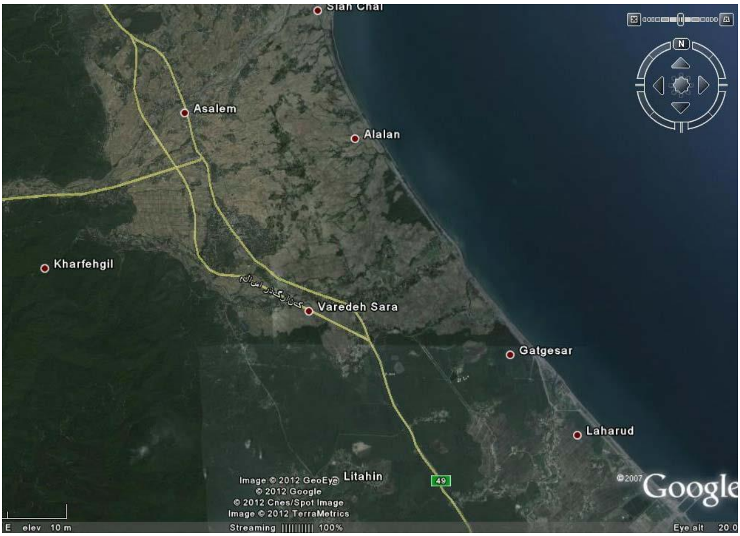

Figure 2: Geographical location and access ways of the studied area (Google Earth satellite map).

Resistivity can be calculated by P=K.V/I formula. In this formula V is the measured potential difference, I is the injected current to the ground, and K is geometry coefficient of the used array. But general formula for calculating this coefficient is as follow:

$$K = 2\pi . \frac{I}{\frac{1}{AM} - \frac{1}{AN} - \frac{1}{BM} + \frac{1}{BN}}$$

If the ground material is homogenous (monotonous), the calculated resistivity on the basis of the equation is constant and independent from the electrode’s distances. But, if the subsurface material is inhomogeneous, the resistivity will change with electrode positions relatively, and however measured value, is called apparent resistivity (a), and is a function of inhomogeneity. In this surveying, two type of arrays carried out:

- Dipole- Dipole array
- Pole- Dipole array
- Wenner array

2-1- Dipole- Dipole Array

This array used to understand variation and development of the subsurface anomaly and obtaining a pseudosection of IP and true- resistivity along one profile. In this array all four electrodes (A, B, M, N) are located along one profile and distance of transmitter electrodes A/B, and receiver electrode's M/N are equal (AB = MN = a). In each measuring electrode's A/B are constant, but electrode's M/N move along the profile, hence, the surveying will be carried out for different depths.

The distance between nearest electrodes of current potential are equal to na (n = 1,2, 3, …), and depth of each measurement is equal to (n+1) a/2, and measured number for point.

2-2- Pole- Dipole Array

In this array, one current electrode (C_1) and potential electrodes (P_1, P_2) are located in one line, and another current electrode (C_2) is located further to the measuring line. The receiver electrodes (P_1, P_2) always are located in one side of the current electrodes (C_1). The distance between current electrode (C_1), and nearest potential electrode is considered equal to na, in which n is greater or equal to one, and A is the distance between potential electrodes (P_1, P_2). With increasing n, the depth of surveying is also increased (Figure 3).

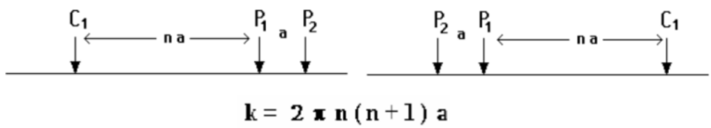

Figure 3: The arrangement of the electrodes in the pole-dipole array (direct and reverse).

In this array, the signal strength is stronger than dipole- dipole array, and similar to pole- pole array is less sensitive to telluric noise. Opposite to other arrays, this array is asymmetrical, that it means at asymmetrical structures, anomalies in pseudo-sections appear asymmetrical. One method for eliminating this effect, is repetition of measuring in the opposite direction.

2-3- Wenner Array

In this array, current electrodes (C_1, C_2) and potential electrodes (P_1, P_2) are located in one line, but receiver electrodes are always located between current electrodes. Distance between all electrodes (C_1, C_2, P_1, P_2) is equal to a, and in each measuring, distance between all electrodes (a) will be increased. Figure 4, shows the arrangement of the electrodes in Wenner array.

The main weakness of the Wenner array is excessive development of the electrodes and time of investigation.

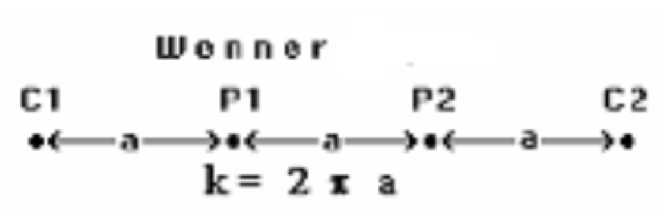

Figure 4: The arrangement of the electrodes in the wenner array.

3- FIELD INVESTIGATIONS IN THE GISUM REGION

In order to detect the fault trace, three profiles with 10 m interval carried out in this area. The first profile located in the beginning of the Gisum Coast with Azimuth 96° and 200 m length. The second profile with Azimuth 73° and 250 m length is located 1.8 km east of the first profile. The third profile with Azimuth 68° and 220 m length, is located 40 m south of profile 2. The location of profiles are shows in Figure 5 & Figure 6.

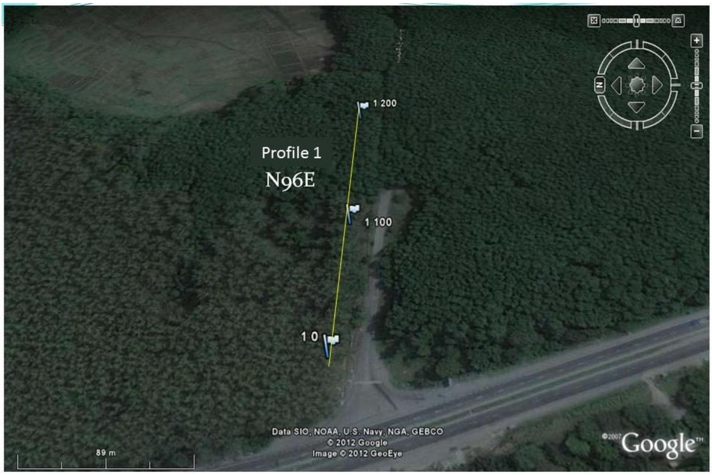

Figure 5: Position of profile one (view from west to east).

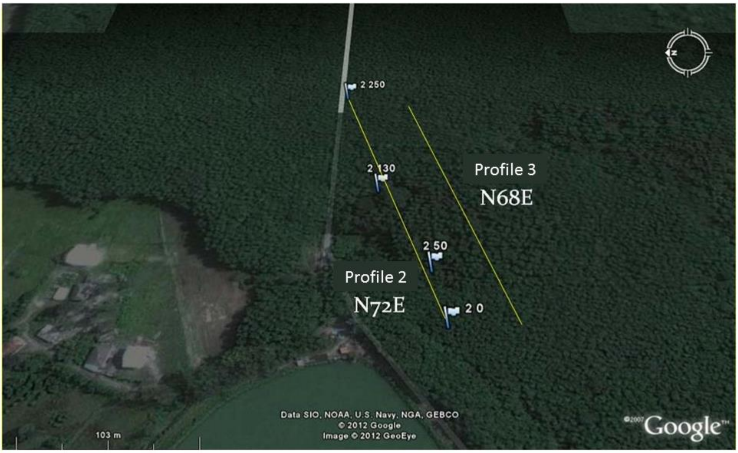

Figure 6: Position of profiles two and three (view from west to east).

The two dimensional resistivity model, obtained in the field, computed by using Res2Dinv software. The two dimensional model used by this program, contain several rectangle blocks (Figure 7). By using this software, it is possible modelled, Pole- Pole, Dipole-Dipole, and Wenner arrays. In this method, with changing the resistivity of the blocks, it is possible to reduce the differences between apparent calculated true resistivity.

This difference will be presented by the root mean square (RMS). Generally, the best method for model selection, is to make use of repetition that RMS error do not change importantly.

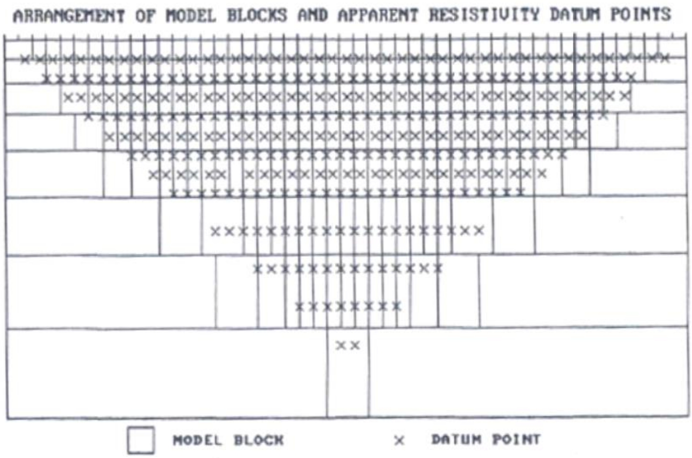

Figure 7: The position of the blocks used in the model relative to the survey points in the pseudo-section.

3-1- Equipment's

Equipment's for measuring resistivity are designed to measure the ground resistance, i.e. proportion of V/I. In this study Swedish resistanmeter model SAS300B used (Figure 8). This model, addition to measuring and omission of self- potential (SP), measures directly proportion of V/I. This type of measurement reduces the errors as minimum as possible.

Figure 8: Resistivity terrameter SAS300B apparatus (Swedish)

4- CONCLUDING REMARKS

In this section, attention is paid to interpretation and conclusion of obtained data. As mentioned earlier, the methods for investigation in the studied region, are Dipole- Dipole, Pole- Dipole, and Wenner arrays.

4-1- Results of Dipole- Dipole Array in Profile 1

The modelled sections of RS prepared with Res2Dinv software. The map of resistivity model, with surveyed pseudosection, and pseudosection obtained from model (Figure 9), and map of the resistivity with topography (Figure 10) are presented. Totally 102 stations measured with RS method.

Discontinuity underneath stations 90 and 110, together with come up of the hydrous layer, and resulted reducing thickness of the surface layer strength, are indication of a probable fault trace in this region.

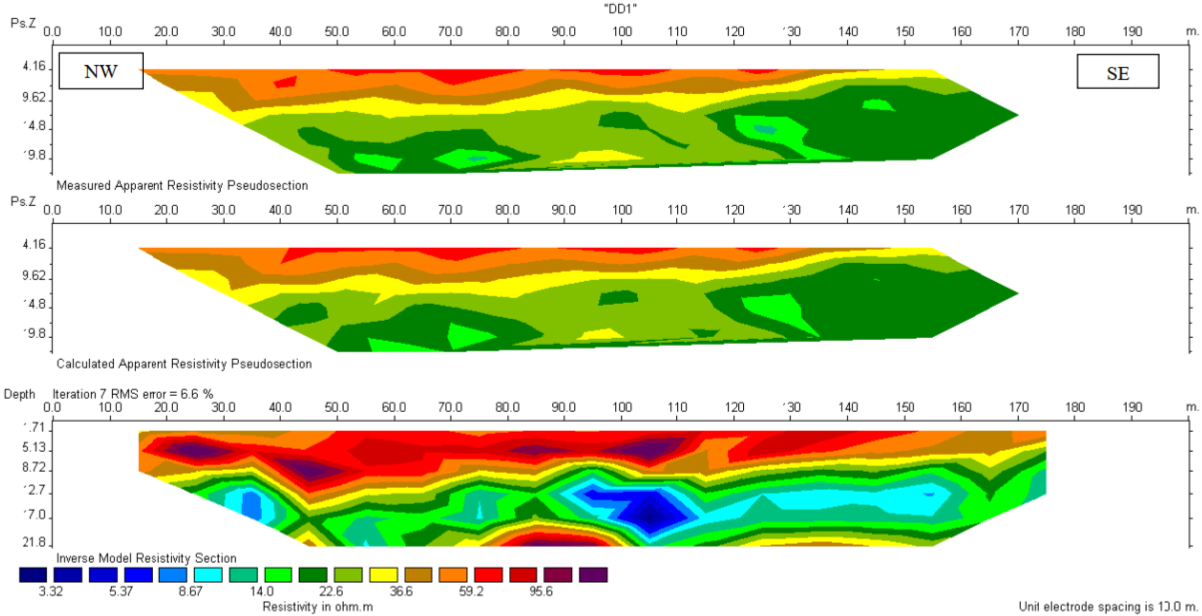

Figure 9: Pseudo-section of true resistivity along with model, profile one.

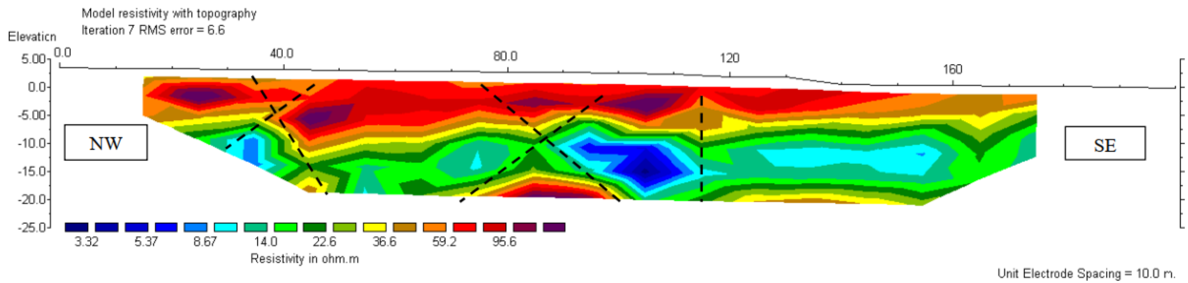

Figure 10: Modelled true resistivity sections by applying topography correction on profile one (dipole-dipole layout).

4-2- Results of Pole- Dipole Array in Profile

The least and most measurement resistivity are 15.8 ohm.m. The RS modelled sections prepared with Res2Dinv software, and modelled RS map together with surveyed section and peudo- section of model (Figure 11), and modelled resistivity map with topography (Figure 12) are presented. Totally 134 stations surveyed with this model.

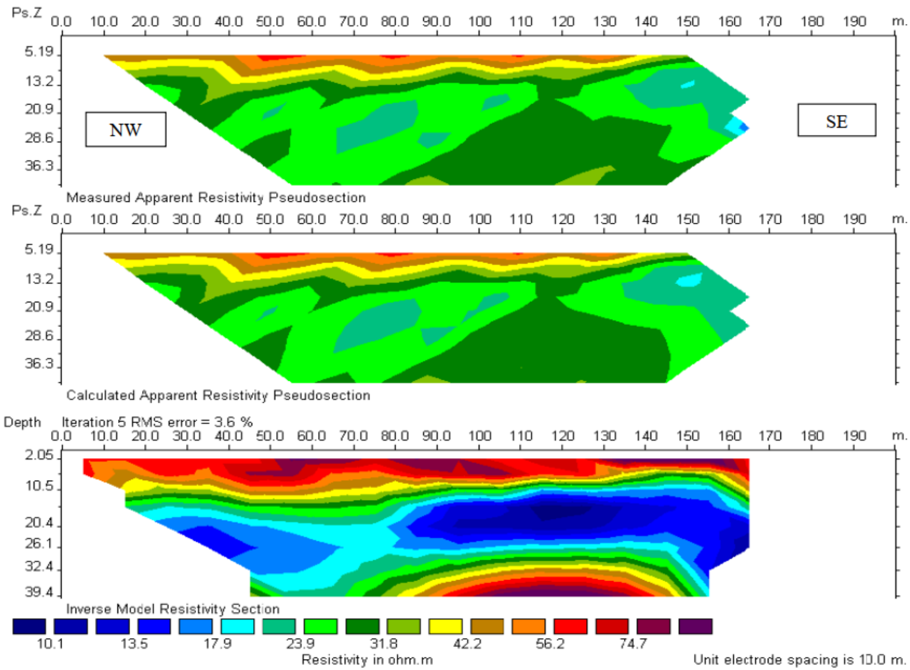

Figure 11: True resistivity pseudo-section together with model, profile one (pole-dipole array).

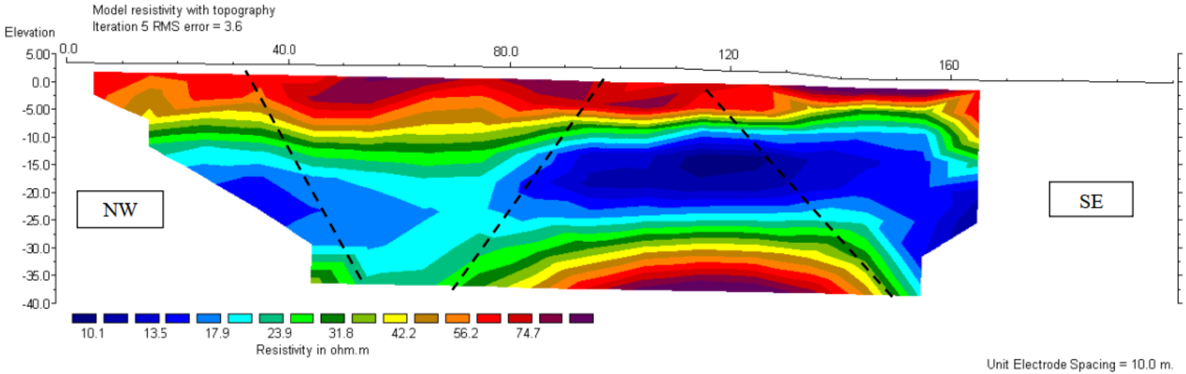

Figure 12: Modelled true-resistivity sections by applying topographical correction on profile one (pole-dipole array).

With respect to RS modelled map, it can be seen that anomaly trend more or less are the same as Dipole-Dipole array but with less details. The strength layer, in this section starts from depth of 25 to 35 m, which probably the depth is deeper than 35 m. In this section, also, the come up of the hydrous layer, and reducing thickness of the surface strength layer is visible. The trace of the probable fault is shown with dashed line in Figure 12.

4-3- Results of the Wenner Array Profile

The least and most measured resistivity values are 17.2 and 68.5 respectively. The modelled RS profiles prepared using Res2Dinv software, and map of the modelled resistivity, together with measured pseudo-sections and pseudo-sections result from modelling are shown in Figure 13, the modelled resistivity map with topography presented in Figure 14. Totally 510 stations measured with this method.

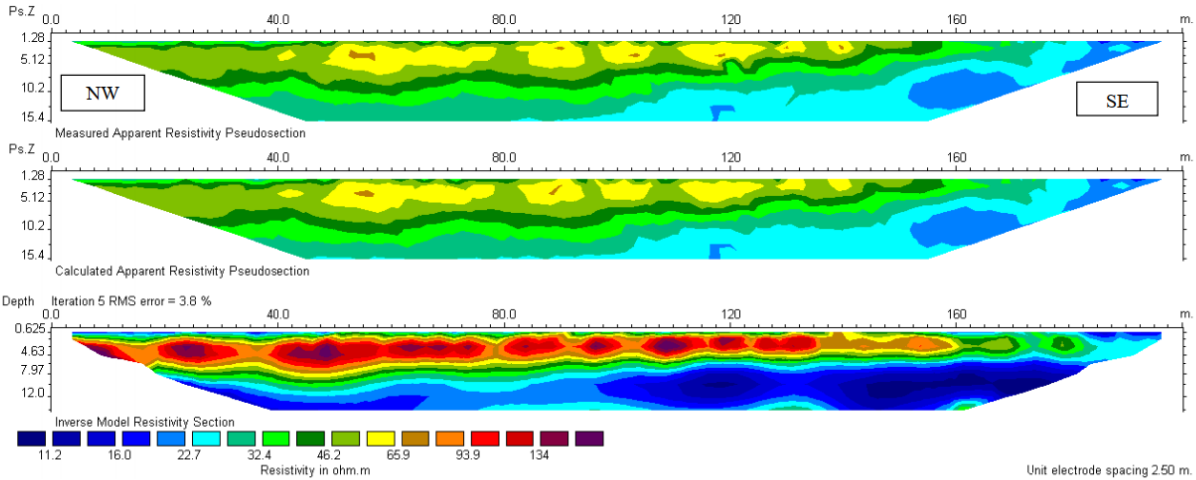

Figure 13: Modelled true-resistivity pseudo-section, profile one (wenner array).

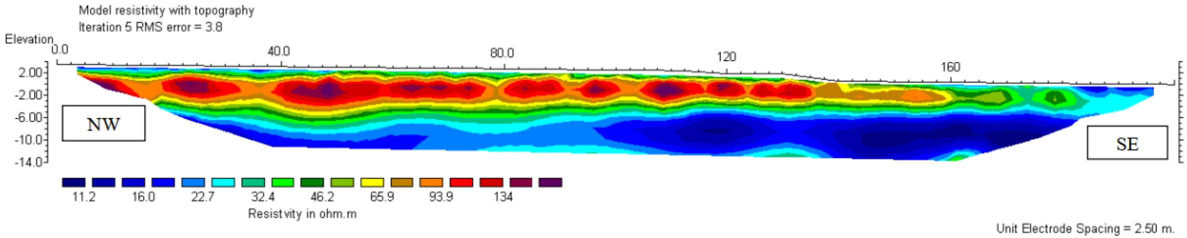

Figure 14: Modelled true-resistivity sections by applying topographical correction on profile one (Wenner array).

On the basis of obtained result it can be concluded that this array with regards to accuracy and details of information is more applicable than other arrays, although the speed and depth of surveying is less in this array. Therefore, Dipole- Dipole array for recognition of fault is better than other arrays in this area.

4-4- Results of 3 Arrays Surveying in Profile 1

Figure 15, shows the results of 3 surveyed sections along profile 1, together with GPS section. In GPS section, due to hydrated material and low electrical resistivity in the ground, the penetration depth is very low (about 2 m), so except surface variations, no data can be obtained from depth and discontinuities. Anomalies from the three modelled sections, especially between stations 70 and 140, show a good agreement between resistant layer in the surface and depth. Of course, in Wenner array due to the short distances of electrodes, more details can be seen from anomalies, although the depth of surveying is low. In contrast, in Pole- Dipole section, the anomalies contain less details.

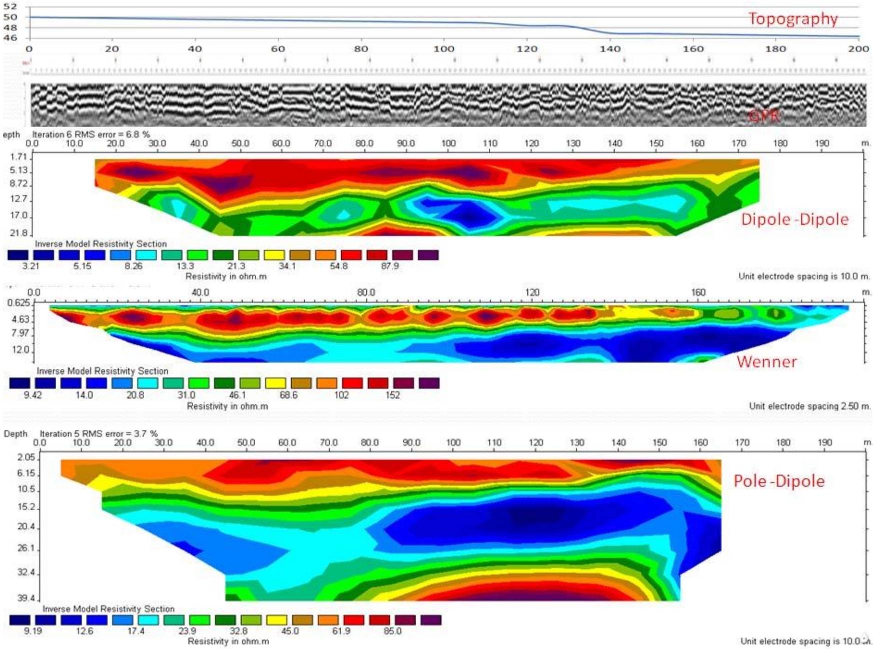

Figure 15: Modelled true-resistivity sections with three different arrays together with GPR section. in profile one.

4-5- Results of Surveying in Profile 2

The results of Dipole- Dipole array with 2 m interval for each station, indicate the least and most resistivity of 13.6 ohm.m and 104 ohm.m respectively. The same array with 10 m interval for each station, indicate the least and most resistivity of 15.3 ohm.m and 49.7 ohm.m relatively. Figure 16, shows modelled resistivity sections, with topography correction and 2 m interval of stations. Figure 17, is modelled resistivity map, with 10 m interval of stations. Figure 18, is map of the modelled resistivity sections with topography. Totally, 422 stations measured with this method.

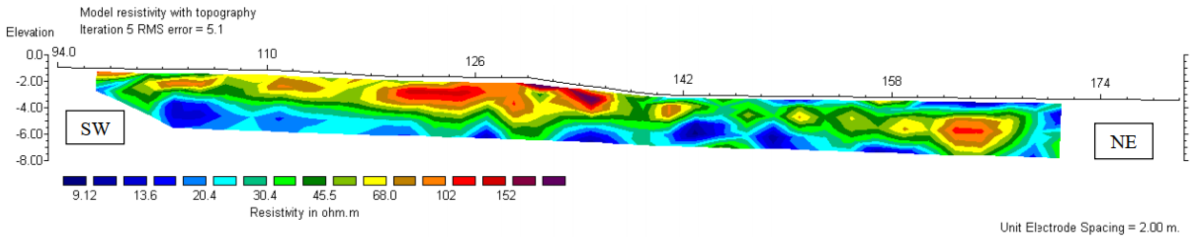

Figure 16: Modelled true-resistivity sections with topographic correction (with 2 m station intervals).

In Figure 16, from the top to the depth of 8 m, there is a competent layer with green to orange color, then a low strength hydrated layer with azure to blue color in the map, can be seen to depth of 15 m, and in some places such as stations 150-160 develop to depth of more than 20 m. Beneath this hydrated layer, there is a layer with high resistivity in a yellow to red color. The buckling of this layer beneath stations 120 to 150, and disruption of layers, might be due to faulting.

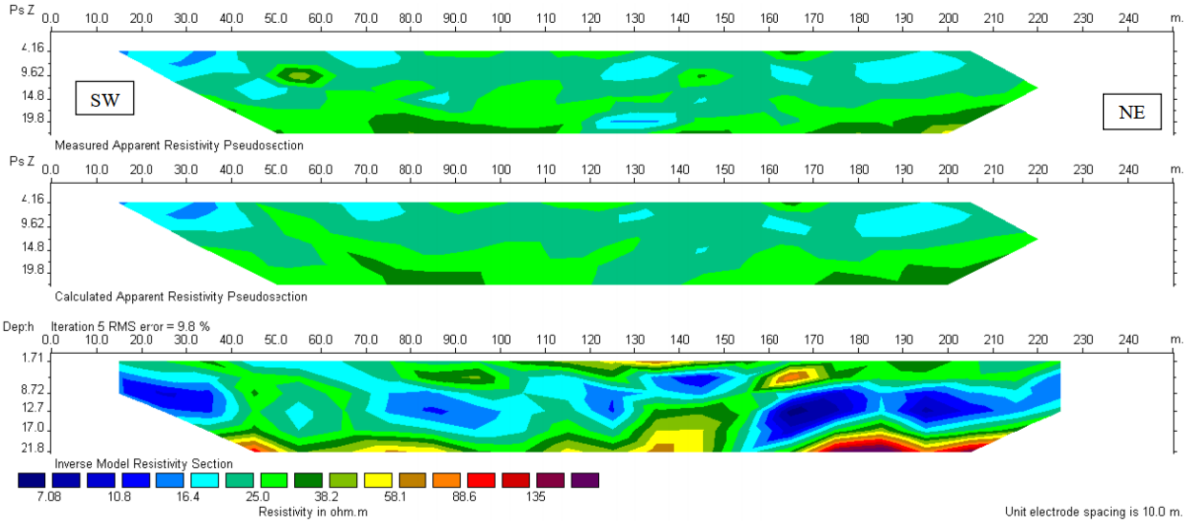

Figure 17: True-resistivity pseudo-sections along with the model (with 10 m station intervals).

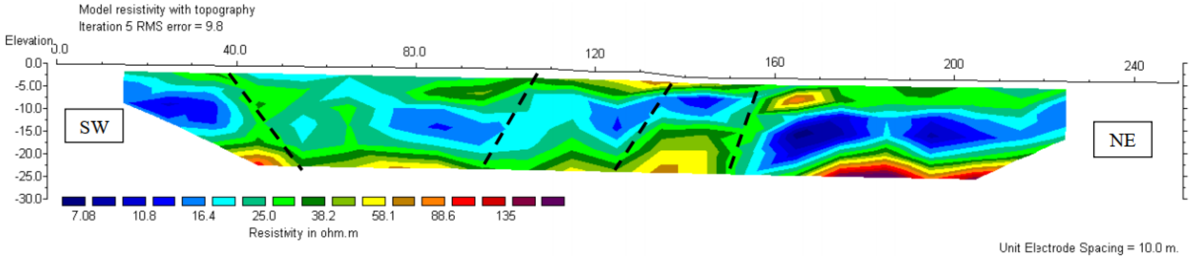

Figure 18: Modelled true-resistivity sections with topographical correction.

4-6- Results of Surveying in Profile 3

The result of Dipole- Dipole array with 10 m interval for each station indicate the least and most resistivity of 15.5 ohm.m to 50.6 ohm.m. Figure 19, shows modelled resistivity profiles, and Figure 20, represent the modelled resistivity map with topography corrections. Totally 126 stations measured for resistivity.

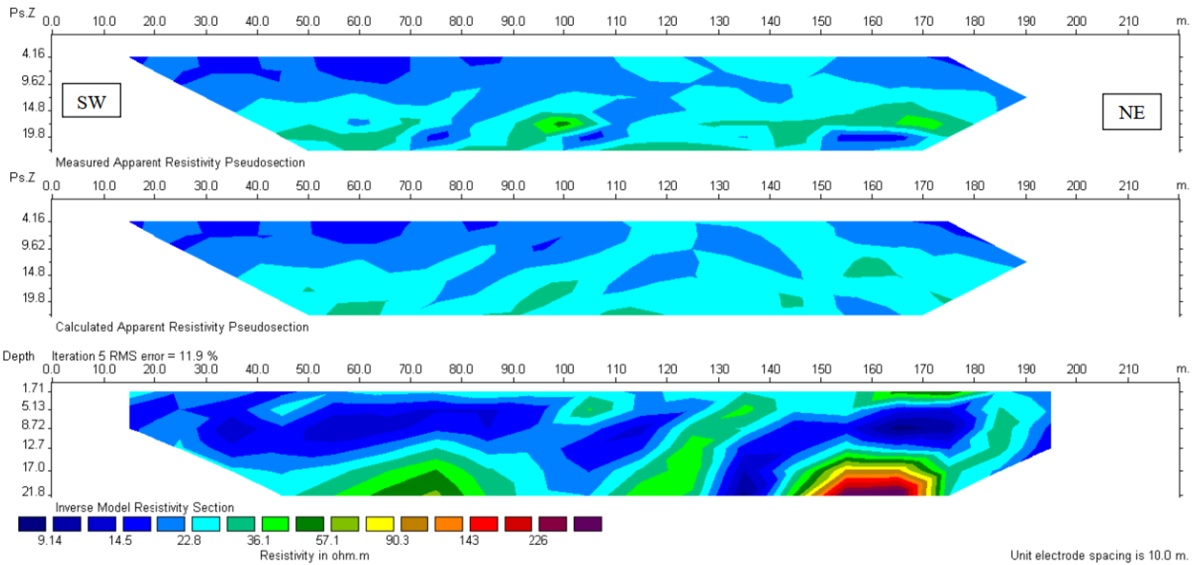

Figure 19: Modelled true-resistivity pseudo-section, profile three.

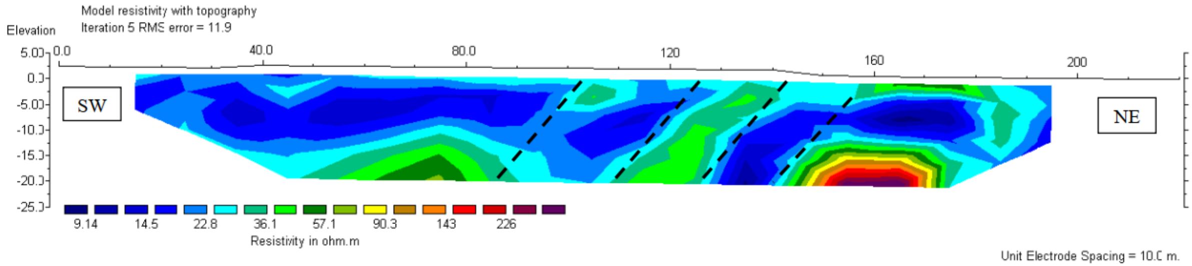

Figure 20: Modelled true-resistivity sections by applying topography correction on profile three.

Based on Figure 20 it can be seen that, the thickness of the competent surficial layer (azure to green layer) and its resistivity decreased. The hydrated layer located in depth of 5 to 12 m. The competent layer of the previous profile which was deep, here is located in depth of 12 m, and even in stations 130 to 140, is very close to surface. This layer contains two discontinuities beneath stations 130 to 140, and 100 to 110. Discontinuities and disruption of layers between stations 100 to 150, might be due to fault movement. The inferred fault, is shown by dashed line in Figure 20. This epigram and trace of faulting can be seen in Figure 21.

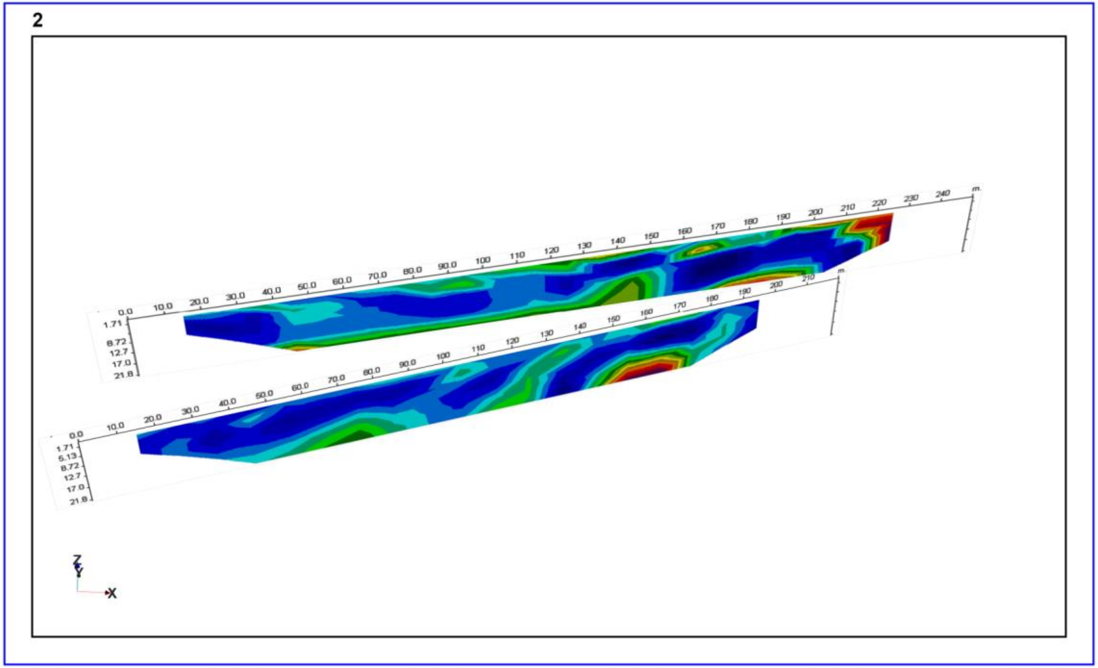

Figure 21: 3D image of modelled true-resistivity sections of profiles two and three.

5- CONCLUSIONS AND SUGGESTIONS

- In this study, three different arrays carried out in profile one for recognition of faulting. Results show the Dipole- Dipole array with regards to the speed of surveying, and obtained details of anomalies is preferable array for fault recognition.
- In order to use Dipole- Dipole array, for obtaining more detail information, it is better to use electrodes with 2 and 5 meters' interval. If the fault is covered by more than 20 m thickness of sediments, the preferred distance of electrodes could be 15 to 20 meters.
- In all three profiles, anomalies which might be related to faulting detected.
- It is suggested, one more profile to be measured near profile 1.