Data processing and interpretation

Preface

The following notes should be mentioned firstly:

1. Qualitative interpretation methods aren't used for interpreting vertical electrical sounding data because these methods rely on lateral changes of the apparent resistivity, and usually not used for detecting vertical changes. Besides, it is expected that the horizontal spread of the contaminants is wide due to ageing of this phenomenon. So looking for lateral changes in this survey, which is restricted to small scale area, is useless.
2. The interpretation of azimuthal resistivity survey data is considered as a qualitative interpretation (especially at the area where azimuthal resistivity survey is applied coincided with VES).
3. All the VES curves are plotted, smoothed and interpreted by computer using IPI2Win program.
4. Manually interpretation of VES data wasn't use (in spite of its important) because:

1. It is found that interpretation by computer is faster and easier, so it can save time.
2. Some standards are used for controlling and evaluating the accuracy of interpretation results as it will be explained later.
3. The automatic interpretation is used instead of manually interpretation (in spite of involving risks sometimes) to get prior information about the electrical parameters and then adjusting these parameters to get more satisfactory and accurate results depending on the shape of the field curve and RMS error percent.

1. IPI2win program

IPI2Win program is designed for vertical electrical sounding and / or induced polarization data curves interpreting along a single profile (Bobachev, 2002). It is presumed that a user is an experienced interpreter willing to solve the geological problem posed as well as to fit the sounding curves. Targeting at the geological result is the specific feature distinguishing IPI2Win among other popular program of automatic inversion.

The foundation of IPI2Win program is the profile interpretation, which means that the data for a profile are treated as a unity representing the geological structure of the survey area as a whole, rather than a set of independent objects dealt separately, but the profile interpretation is implemented mainly by using the semi-interactive mode rather than the automated interpreting.

IPI2Win program is capable of solving electrical resistivity prospecting 1D forward and inverse problems for a variety of commonly used arrays for the cross section with resistivity contrasts within the range of 0.0001 to 10000.

The forward problem is solved using the linear filtering. The thoroughly tested filter and filtering algorithm implementation provide fast and accurate direct problem solution for a wide range of models, covering all reasonable geological situations.

The inverse problem is solved using a variant of Newton algorithm of the least number of layers or the regularized fitting minimizing using Tikhonov's approach to solving incorrect problems. Priory information on layers depths and resistivities can be used for regularizing the process of the fitting error minimizing. The inverse problem is solved separately for each sounding curve. The IPI2Win authors suppose that the approach involving interactive semi-automated interpreting preferable taking both the effectiveness and the geological sense into consideration. This approach provides the opportunity of more complete and accurate taking a priory data into account. Some of these, being rather of descriptive than quantitative nature, can hardly be introduced as formal parameters into the interpreting model. In this case the interpreter's experience and geological erudition may occur to be of even greater importance than the calculation accuracy.

The program is also designed for presenting results of VES interpretation in the form of pseudo cross section by drawing VES-points along the horizontal axis and values of apparent resistivity (ρ_a) for each (AB/2) along vertical axis.

The program is also capable to present the results of VES interpretation in the form of geoelectrical section by drawing the VES-points along the horizontal axis and the horizons depths along vertical axis.

This program has many options that make it preferential:

1. It is capable of solving electrical resistivity prospecting forward and inverse problems for automated curve interpretation to create a model with least quantity of layers without priory information on layers thicknesses and resistivities, and semiautomatic interpretation to create a model using a priory data, derived from the manually interpretation or geological data.
2. It is possible to editing the model parameters manually using the mouse throw altering the quantity of layers by means of splitting (add layer) or joining (remove layer) them and changing the properties of the layers.
3. Estimating the equivalence limits for all of the model parameters for a certain sounding point and calculated the uncertainty of every one of the model parameters.

Interpretation of azimuthal resistivity survey data near contaminated well 2

Because we couldn't complete a circle of 360°, we plotted the result in a Cartesian coordinates instead of rosette diagram because it is more representative as in figure (4.1).

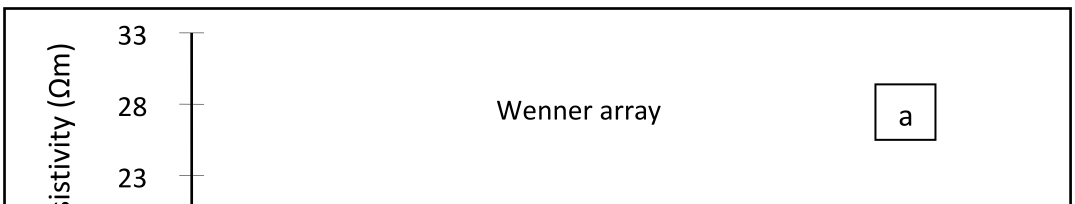
Figure (4.1a) shows the azimuthal diagram of Wenner array, the plot shows a decrease in apparent resistivity values with direction from (30°) where the apparent resistivity was (10.9Ω.m) till we reach direction of (90°) where the measured apparent resistivity value was (13.4Ω.m), and with changing the azimuth the measured apparent resistivities begins to rise again till we reach the azimuth degree (120°) where the measured apparent resistivity was (17.4°). We see that there is a negative anomaly confined between the directions (30°) and (90°) which is could be due to underground flow of contaminated water plume where it is spread under surface at investigated depth of about (2m).

Figure (4.1b) shows the azimuthal resistivity diagram of Schlumberger array. The graph of Schlumberger array is approximately same as the graph of Wenner array, and that may be due to investigate the same depth approximately.

Figure (4.1c) shows the azimuthal resistivity diagram of polar dipole-dipole array. The plotted graph is differs from Wenner and Schlumberger graphs in two general points:

1. There is an increase in measured apparent resistivity values.

2. The shape of the graph differs, where it reflects a sharp negative anomalous value at azimuth direction of (60°) where the measured apparent resistivity is (10.4Ω.m).



A relative increase in apparent resistivity with depth is expected because the top layer could be affected by the flowing out water from the well decreasing its apparent resistivity. Therefore the general increase in the measured apparent resistivities with polar dipole-dipole array means that the investigated depth by using this array is greater than that by using Wenner and Schlumberger arrays, because, theoretically, investigated depth using polar dipole-dipole array is greater than that investigated by Wenner and Schlumberger arrays.

From figure (4.1c) it is clear to note that the response of polar dipole-dipole array curve to the subsurface plume is better than that for Wenner and Schlumberger arrays and this because either the subsurface plume gets narrower with depth or the resistivity contrast between that plume and the back ground sediments getting sharper with depth or both reasons.

In general, from figure (4.1) it's concluded the following:

1. Due to infiltration of the contaminated flowed out water from the well, a subsurface plume of contaminated water was formed, this plume is spreading over all the covered area, and it gets narrower with depth.

2. The plume is moving with the general slope direction which is same direction of ground water flow, spreading over an area confined between directions (30°) and (90°) where (60°) direction represents the central axis of the plume which is approximately the direction of ground water as illustrated in figure (4.2).

3. All the used arrays (Wenner, Schlumberger and polar dipole-dipole) show the ability to delineate the contaminated water plume, but there was a difference in that ability, where polar dipole-dipole array was the best to delineate the exact axis of the subsurface plume and that support the theory of being better in detecting horizontal changes in apparent resistivity.

4. From the obtained results, it can be said that the azimuthal resistivity technique can be used to delineate underground contaminated water plume at site conditions such as:

    1. The apparent resistivity contrast between the plume and the background sediments must be detectable.

    2. The spreading area must not be wide.

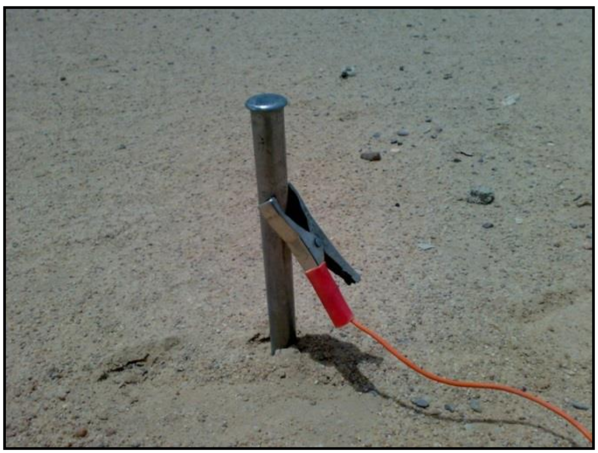
    3. The ground water must be deep enough to allow detecting the plume at the area confined between surface and ground water level.

    4. At such studies must take in account the general slope direction of the site because the plume is taking that direction to move from the source to the surroundings.

We found that (by practice) the acceptable value of (q) is must not exceed 3 or else the measurements will include some error.

The following field mistakes (usually) increase the value of (q):

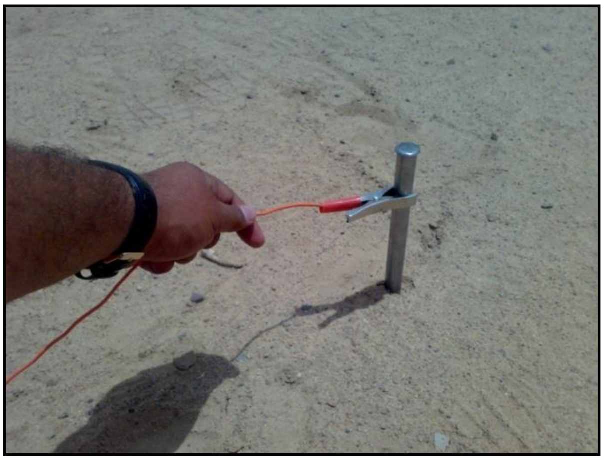
- Bad connection between the electrode and the ground.



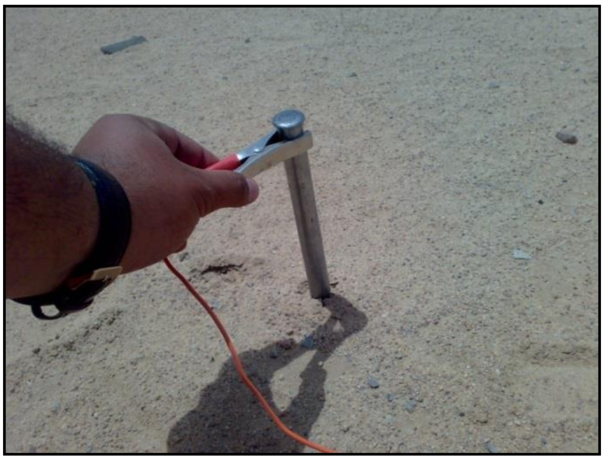
- Bad connection between the electrode and the cable (or clips cord).

- One (or more) of the electrodes was stick inclinely which may cause bad contact between this electrode and the ground. See plate (3.3).

- Touching the cable during the measuring operation. See plate (3.4).



- Touching the electrode or the clips cord during the measuring operation. See plate (3.5).



- Putting the clips cord nearly the ground surface while it is connected to the electrode. See plate (3.6).

References

AL-Menshed, F.H, 2011. Evaluation of resistivity method in delineation ground water hydrocarbon contamination southwest of Karbala city. Unpublished, PhD thesis. University of Baghdad, college of science