جامعة الانبار

كلية العلوم -قسم الجيولوجيا التطبيقية

اسم المادة بالعربي: الجيوفيزياء الجهدية - الطرق الكهربائية

اسم المادة بالإنكليزي: **Potential Geophysics- Electrical Methods**

عنوان المحاضرة : **(CST) Constant Separation Traversing Approach**

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(CST) Constant Separation Traversing Approach.

The object of electric horizontal profiling or combined Traversing approach is to detect the lateral variations in the resistivity of the ground. In Schlumberger method of electrical profiling, the current electrodes (AB) remains fixed at a relatively large distance, for instance, a few hundred meters, and the potential electrodes (MN) with a small constant separation (Sharma , 1986).

The appearance of the resistivity profile obtained by horizontal profiling will depend not only on the positions of the potential electrodes M and N, but also on the positions of the current electrodes A and B with respect to the inhomogeneities in the earth and the reason behind that is that all electrodes are moved after each measurement (Kunetz, 1966).

The effect of vertical structures e.g. (faults, fissures, dikes, veins, and shear zones) is lateral. If these features crop out, abrupt discontinuities in the slope of (ρa) curves are obtained as the mobile electrode configuration crosses the vertical resistivity boundary. Many of key features found in the resistivity anomalies over a vertical fault are found also in anomalies over near vertical structures. The fault represents a vertical contact problem between two media of differing resistivity. Therefore, the calculated curves for (ρa) are discontinuous at the vertical boundary. The discontinuity will be evident in practice as a steep gradient in the resistivity curve (Sharma, 1986).

The traversing obtained by moving an electrode spread with fixed electrode separation along a traverse line, the array of electrodes being aligned either in the direction of the traverse (longitudinal traverse) or at right angles to it (transverse traverse). The former technique is more efficient as only a single electrode has to be moved from one end of the spread to the other, and the electrodes reconnected, between adjacent readings. The Vertical discontinuity distorts the direction of current flow and thus the overall distribution of potential in its vicinity. (VES) data from several soundings can be presented in the form of a pseudosections and it is now possible to invert the data into a full, two-dimensional geoelectric model rather than a sequence of discrete, uni-dimensional geoelectric sections. This technique is known as electrical imaging or electrical tomography (Kearey et.al, 2002).

The advantage of using several line lengths (several AB spacing's) in the horizontal profiling or is undertaken either to study layers at several different depths, or, more often , to facilitate the distinction between structures that are indistinguishable because they produce overlapping effects at the surface (Kunetz, 1966).

The interpretation of resistivity profiles is usually qualitative in nature. The effects of subsurface structures are located by the abrupt lateral changes in (ρa) profiling curves. The (ρa) varies over a vertical boundary differs considerably between the various electrode arrays (Keller, 1970).

The lateral inhomogeneities in the ground affect resistivity measurement in different ways. The effect depends on: (1) the size of the inhomogeneity with respect to its depth of burial, (2) the size of the inhomogeneity with respect to the size of electrode array, (3) the resistivity contrast between the inhomogeneities and the surrounding media, (4) the type of electrode array used, (5) the geometric form of the inhomogeneities, and (6) the orientation of the electrode array with respect to the strike of inhomogeneities (Zohdy et al , 1990).

Iso-Apparent Resistivity Maps.

The apparent resistivity map has numerous applications since the advent of electrical prospecting and considered very useful on large scales. Its principal advantages lie in the ease of making field measurements and simplicity in qualitative interpretation of results. Once they are free from various electrode effects, the apparent resistivities reflect the corresponding variation in the true resistivities in a zone has a fairly well known (nearly constant) depth. One of electrical sounding advantages is that it permits continuous coverage which makes them preferable for detailed surveys of features such as semi vertical faults. The fact, the possibilities of the resistivity map are fairly limited, when it comes to defining precisely the nature and the form of structures, which is not a major inconvenience. In preliminary surveys subsurface object reveal different anomalies when studied in details by other methods. Therefore resistivity mapping attempts to localize shallow contacts or facies variations such as faults and constructive pockets. In the interpolation of a certain geophysical parameter, such as (resistivity), the depth to a given bed is determined precisely at some certain points in the investigated area by using expensive methods such as well drilling. While in simple cases, the apparent resistivity could be calibrated by drawing structural contours that gives predicted depths directly (without additional well drilling). This has been done, for example, in the Joplin district (USA) and near Hettenschlag (Alsace), (Kunetz, 1966).

Space Sections.

The space section represents an apparent resistivity section which considered by plotting the apparent resistivity (ρa) , as observed , along vertical lines located beneath the sounding stations on the chosen profile. The apparent resistivity values are then contoured; Figures (14 and 15). Generally a linear vertical scale is used to suppress the effect of near- surface layers. It represents one of the important constituents of qualitative interpretation (Zohdy et al., 1990).

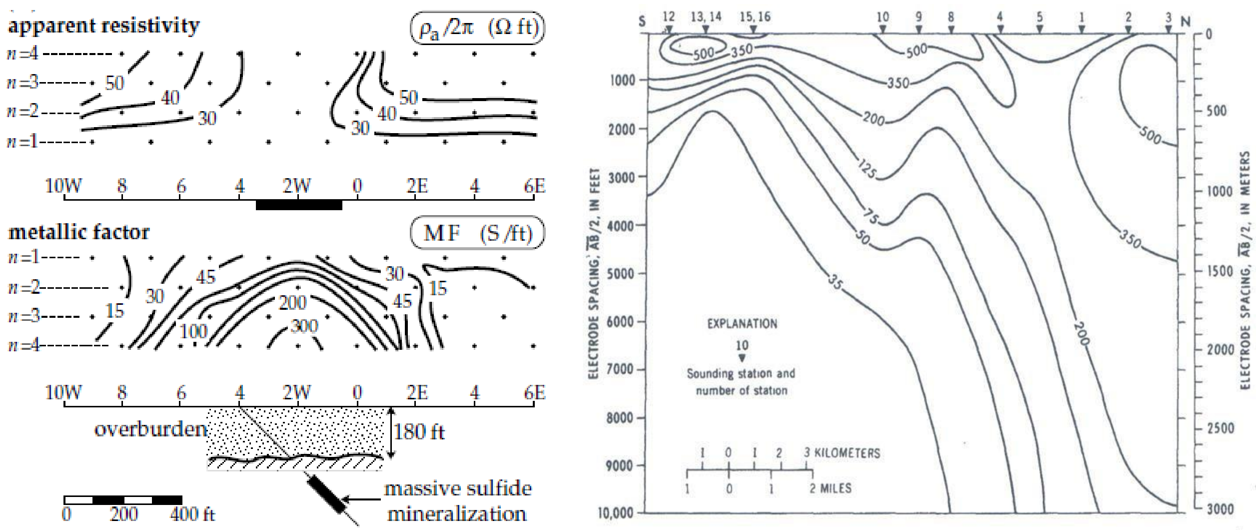


Figure (14): Pseudo depth section near Minidoka , Idaho. Values on contour lines designate apparent resistivities in ohm.m, Snake River basalt thickness toward the north. After (LOWRIE W,2007), (Zohdy et al., 1990).

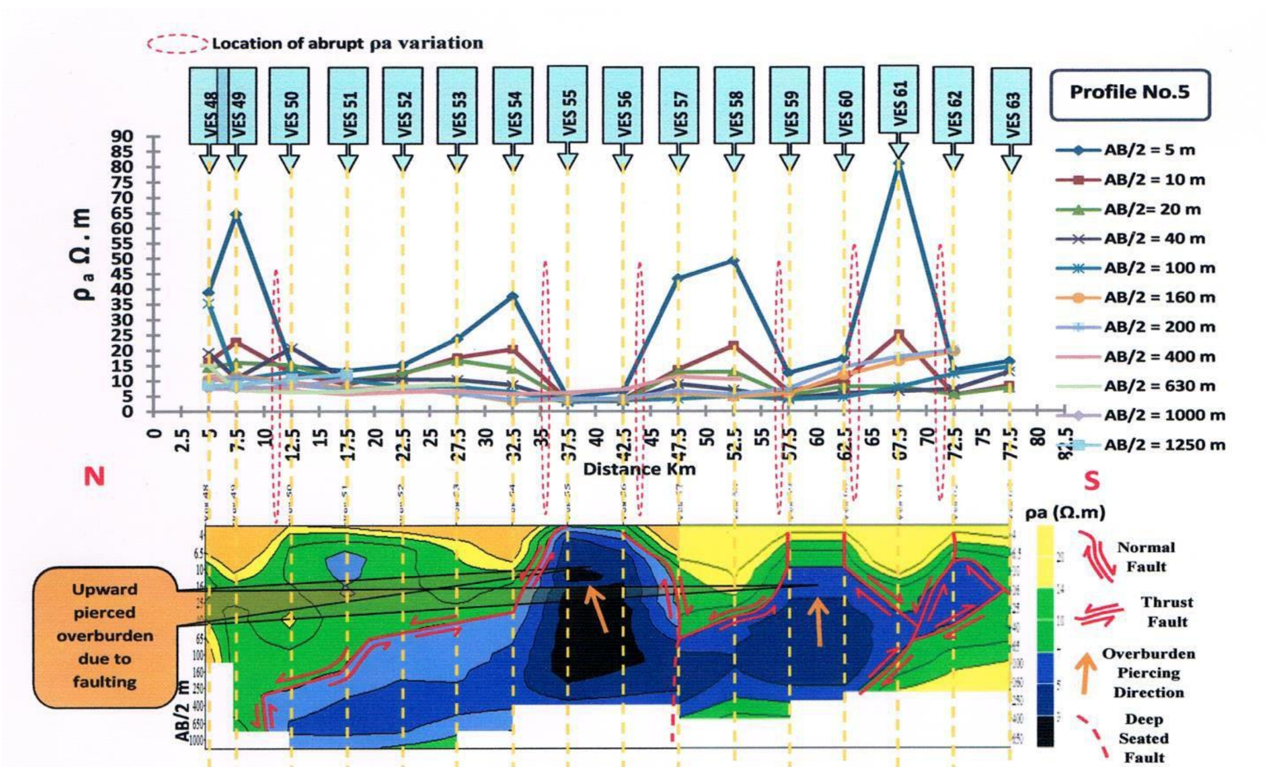


Figure (15): Spacing section and Pseudo depth section for the same profile line which composed of 16 VES points, (AL-Khafaji, 2014).

Quantitative Interpretation

Resistivity Curves Interpretation by using the Auxiliary point Method.

The sounding resistivity curve quantitative interpretation requires that the field curves be drawn on transparent bilogarithmic paper of the same modulus as used in the master curves. An improvement on this procedure is to plot the field data onto plain transparent paper which can then be superposed onto the bilogarithmic paper as necessary. This facilitates curve matching and tracing. Before proceeding with the interpretation by using Ebert method, the interpreter must decide that his field curve represents a structure of two, three, four or more layers. Occasionally the appearance can be misleading; some three-layer curves look superficially like two-layer curves and a similar statement applies to multi-layer curves. Curves representing five or more layers can be interpreted by means of auxiliary point method. When the number of layers reaches to five or six, interpretation becomes complicated **(**Orellana and Mooney, 1966**)**.

In the partial curve matching each part of the curve will be interpreted relatively to the part before. The first curve part is the most important one in interpretation where a special care must be taken during matching to insure best matching resolution to find the ratio ρ2/ρ1. Because the matching resolution for the following parts of the curve will depend on the first part matching resolution. In other words the positions of crosses during interpretation are relative to each other and they are drawn relatively to the first cross. Figures (16 and 17), shows manual drawn sounding field curves before and after smoothing. The detailed steps for interpreting a resistivity sounding curve by using Ebert method could be found in (AL-Khafaji, 1999).

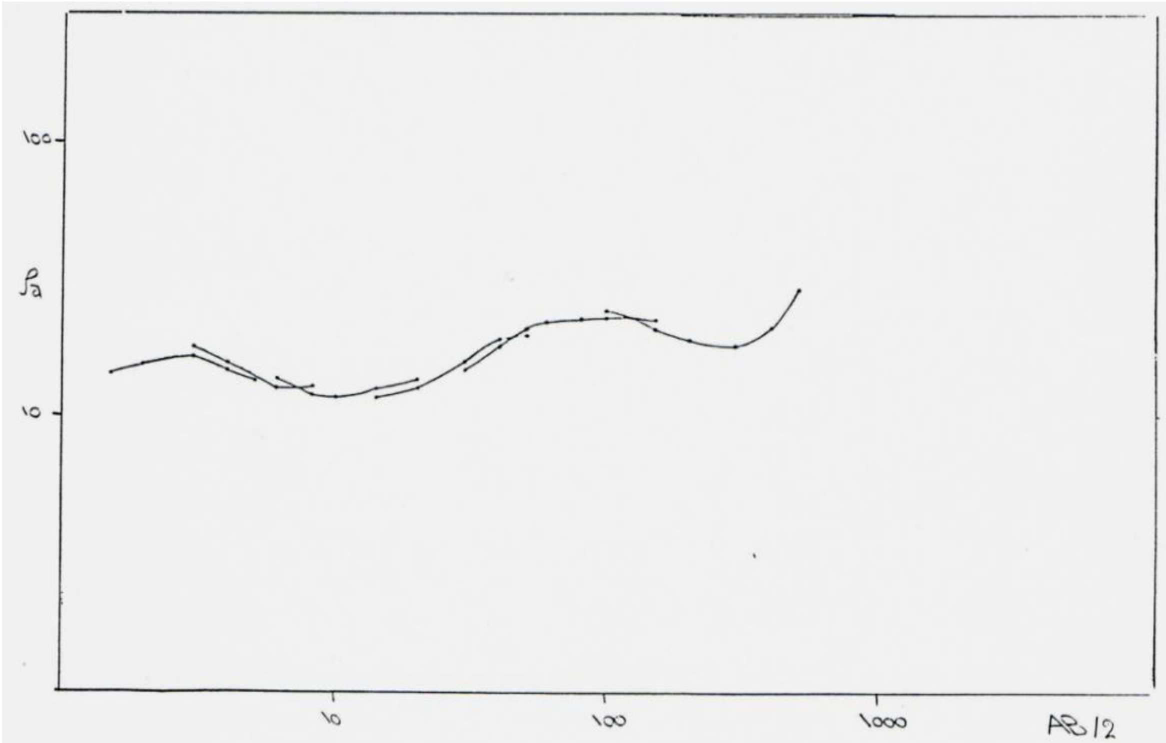


Figure (16): Schlumberger Sounding curve before smoothing shows the discontinuous MN segments, After (AL-Khafaji, 1999)

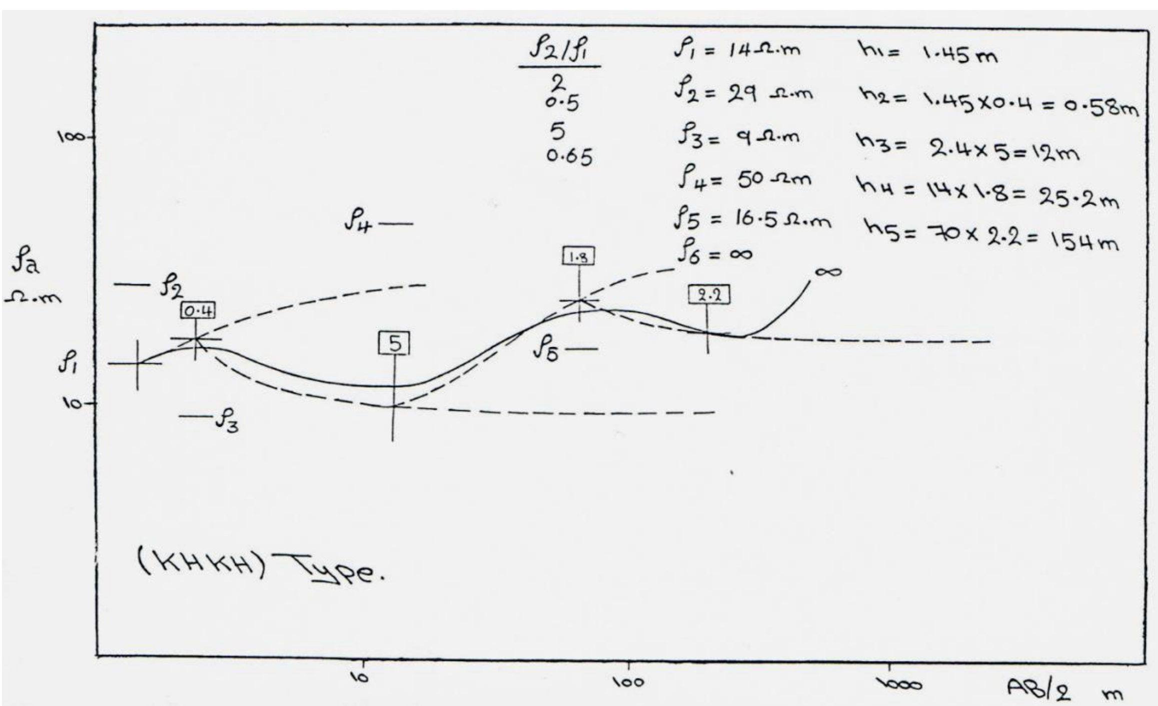


Figure (17): Schlumberger Resistivity sounding curve after smoothing, (AL-Khafaji, 1999).

The field data of VES point could be fed to computer software. This procedure require a special care that interpretation results must agree with the nearby subsurface lithology information which obtained from boreholes or well logging graphs if available. An example of such reliable computer software is the (IPI2Win) software.

The data input to a computer software specialized for (VES) processing, interpretation and results enhancement. The software usage is useful in enhancing the manual interpretation results during curve interpretation. This has been noticed during software usage:

1- The software is reliable during curve smoothing and discontinuity treatment.
2- It is able to treat ambiguity that related to principal of equivalence and suppression by reducing the predicted resistivity layering number as much as possible.
3- The reduction of (r m s %) between the calculated and the field curve as much as possible.

The software uses the common forward and inversion technique (IPI2Win, 2001). Figure (18 and 19), shows one of the processed and interpreted VES points , first manually and ,second by attending (IpI2Win) computer software, for the same VES point.

It's important to mention that the enhancement of (VES) results by using such computer software should be attended very carefully without effecting the actual thickness values of layers which assisted by boreholes information. Therefore, it would be better to interpret the sounding curve manually at first then enhancing this interpretation by using the computer software.

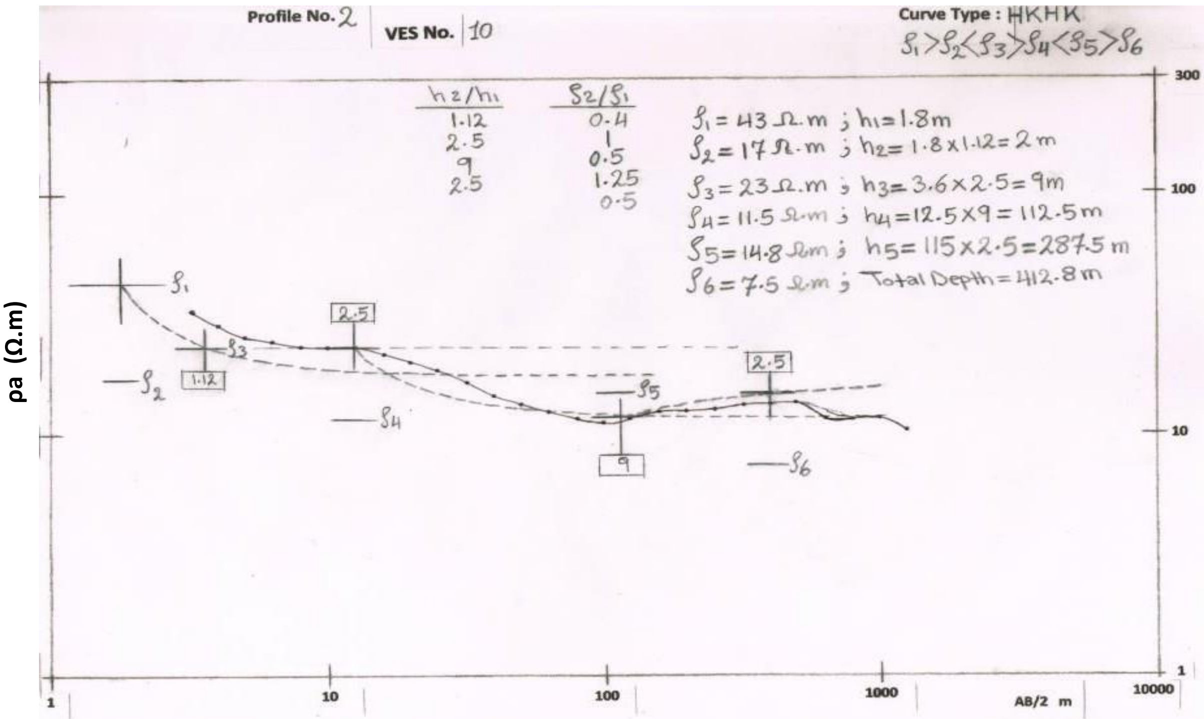
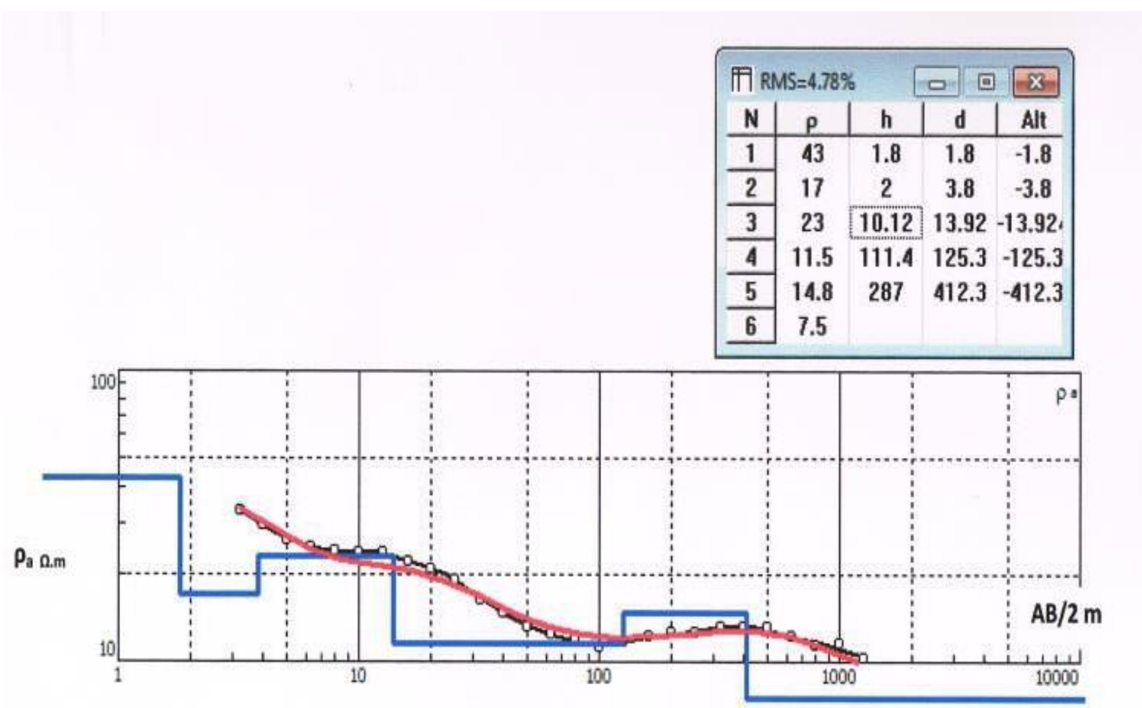


Figure (18): Profile No.2; VES No.10 manual interpretation using the auxiliary point method technique.



RMS=4.78%

N	ρ	h	d	Alt
1	43	1.8	1.8	-1.8
2	17	2	3.8	-3.8
3	23	10.12	13.92	-13.92
4	11.5	111.4	125.3	-125.3
5	14.8	287	412.3	-412.3
6	7.5			

Figure (19): Profile No.2; VES No.10 interpretation using computer software.

It’s important to mention that a special care must be taken when enhancing the curve interpretation using this software and this could be briefed by the following:

1- The reduction of rms% could be achieved by changing the field curve very slightly to make it more matched with the calculated or theoretical curve during what is called forward and inversion method. Therefore its preferable to keep the layers thickness (h) values which is assured by manual interpretation and borehole information constant. The common change will happen slightly on (ρ) values in a logical amount that agree with the geological conditions.
2- The curve type must remain the same of the manual interpretation, so that the interpreter who uses such software must always check out the changes that might happen on the curve type during his enhancement operation. If the curve type changed then the interpretation will be inaccurate.
3- During the drawing of resistivity and pseudo depth sections, it is very important to check out the depth of investigation because the software has the ability to extend a proposed depth on the section which is sometimes not desired by the interpreter. So that, sections depth must be logical according to the array current electrodes (AB) distance which is the main balance of investigation depth and these depths must be always compared with the lithology and hydrology of the boreholes which are close to the sounding points.
4- Its preferable to draw the geoelectrical sections after studying the resistivity ranges of rock layers in the study area with the assistance of the software drawn resistivity sections. The reason behind this is that software depends

on the absolute layers resistivity values when connecting the geoelectrical zones. While the interpreter may use the rock resistivity ranges during the drawing of the geoelectrical sections. So that a combination between software displays and interpreter improvisations must be attended to give the best subsurface geological picture about the rocks electrical zones.

The three major steps of interpreting the VES resistivity curve are:

1- The manual drawn sounding curve before smoothing that shows discontinuous MN segments of the curve.
2- The manual smoothed and interpreted sounding resistivity curve by using the auxiliary point partial curve matching method. This method achieved by using the two layers standard curves set of Orellana and Mooney, 1966.
3- The enhanced resistivity curve by using the (IPI2Win) computer software. This enhancement represented by more accurate smoothing, treatment of equivalence and suppression and the reduction of r m s% to give more accurate results.

The final sounding curves interpretation results after enhancement could be tabeled in the form which appear in figure 20.

The (VES) interpretation results represent the thickness (h) in meter and resistivity(ρ) in ohm.m for each of the electrical zones within each of the (80) geoelectrical columns located under the midpoints of the (VES) points in the study area. Table (2-3), shows a sample of the results that obtained after interpretation.

VES No.	ρ1	h1	ρ2	h2	ρ3	h3	ρ4	h4	ρ5	h5	ρ6	Total Depth m	Curve Type
1	76.8	2.3	16.8	254	32.5							256.3	H
2	375	2.77	20.1	1	9.82	280	16.3	178	8.37			461.77	QHK
3	302	1.43	5.96	6.79	11.5	7.13	8.83	73.5	12.8	375	5.07	463.85	HKHK
4	103	1.72	46.3	3.93	18.6	48.9	8.27	192	12	405	10000	651.55	QQHA

Figure (20): A sample of interpretation results for the (VES).

Reference

Wadhah M. Shakir (2021) Electrical Geophysical Methods AL-Karkh University of Science, College of Geophysics and Remote Sensing, Department of Geophysics. **77** PUBLICATIONS **36** CITATIONS.

Kearey P. , Brooks M. , Hill I., (2002) An Introduction Geophysical Exploration", 3rd ed. Blackwell Science Ltd., USA, 281 pages.