جامعة الانبار

كلية العلوم -قسم الجيولوجيا التطبيقية

اسم المادة بالعربي: الجيوفيزياء الجهدية - الطرق الكهربائية

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

عنوان المحاضرة: **Vertical electrical Sounding (VES) Resistivity Curves**

اسم المحاضر: الاستاذ الدكتور علي مشعل عبد حمد الحلبوسي

Vertical electrical Sounding (VES) Resistivity Curves

The next step is to draw the apparent resistivity curve on a log-log paper designed especially for this reason, each MN\2 spacing drawn as a separated segment then these segments will form the whole shape of the curve, figure 6. In this figure the sounding resistivity curve is called unsmoothed curve as it composed of segments and these curve segments may show vertical and horizontal shifting from each other. This is mainly produced by the effect of heterogeneity or inhomogeneity of subsurface rock layers. The curves must be smoothed to solve resistivity curve discontinuities, Figure 6 , which produced by different (MN) spacing's of the same(AB) spacing's and mainly caused by the lateral heterogeneity and anisotropy.

VES No.				
AB	MN	AB/2	MN/2	ρa Ω.m
6.4	2	3.2	1	268.5
8	2	4	1	220.7
10	2	5	1	173.4
12.6	2	6.3	1	118.5
16	2	8	1	70.7
20	2	10	1	40.4
25	2	12.5	1	24.8
32	2	16	1	16.97
40	2	20	1	14.2
40	20	20	10	22.1
50	20	25	10	13.2
50	2	25	1	13.2
64	20	32	10	10.7
80	20	40	10	10.3
100	20	50	10	10
126	20	63	10	10.2
160	20	80	10	10
200	20	100	10	10.3
250	20	125	10	10.62
320	20	160	10	11.03
320	20	160	10	10.13
400	100	200	50	10.3
400	100	200	50	11.05
500	20	250	10	10.6

Figure (5): a table arrangement to record the information of one VES point by using Schlumberger electrodes configuration

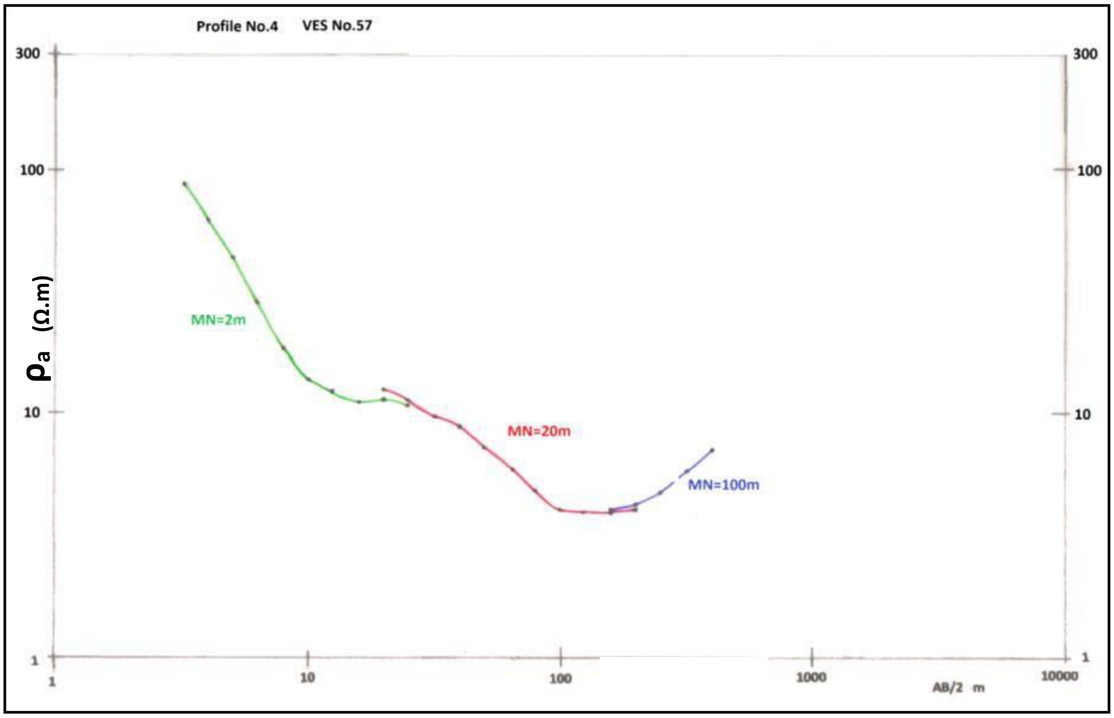

Figure (6): The unsmoothed VES resistivity curve showing the MN segments.

The scales of the both curve axes are logaretmic. After the above procedures the curve must be smoothed by eliminating the shifted segments in order to prepare it for interpretation, figure 7. The smoothing attended by shifting the discontinued curve segments of the same AB/2 spacings but with different MN/2 spasings upward or downward in order to obtain a smoothed curve like the one appears in Figure 7. This procedure also corrects curve deformations that may produced by heterogeniety.

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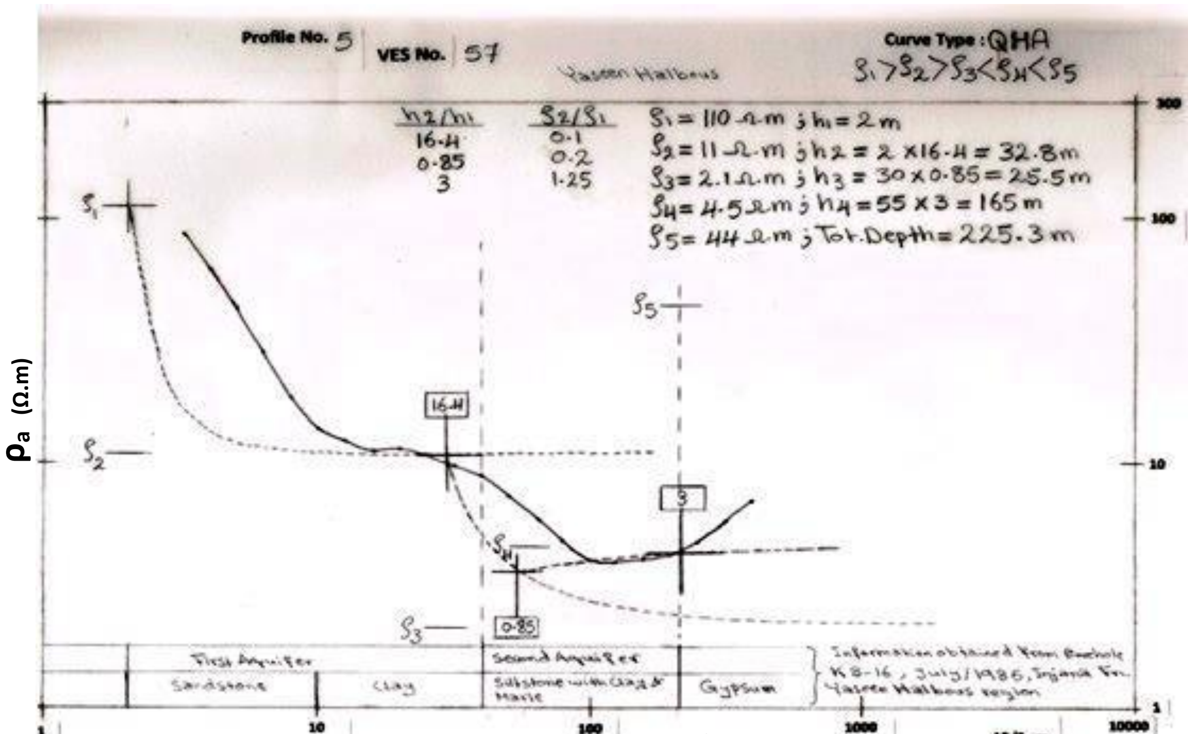
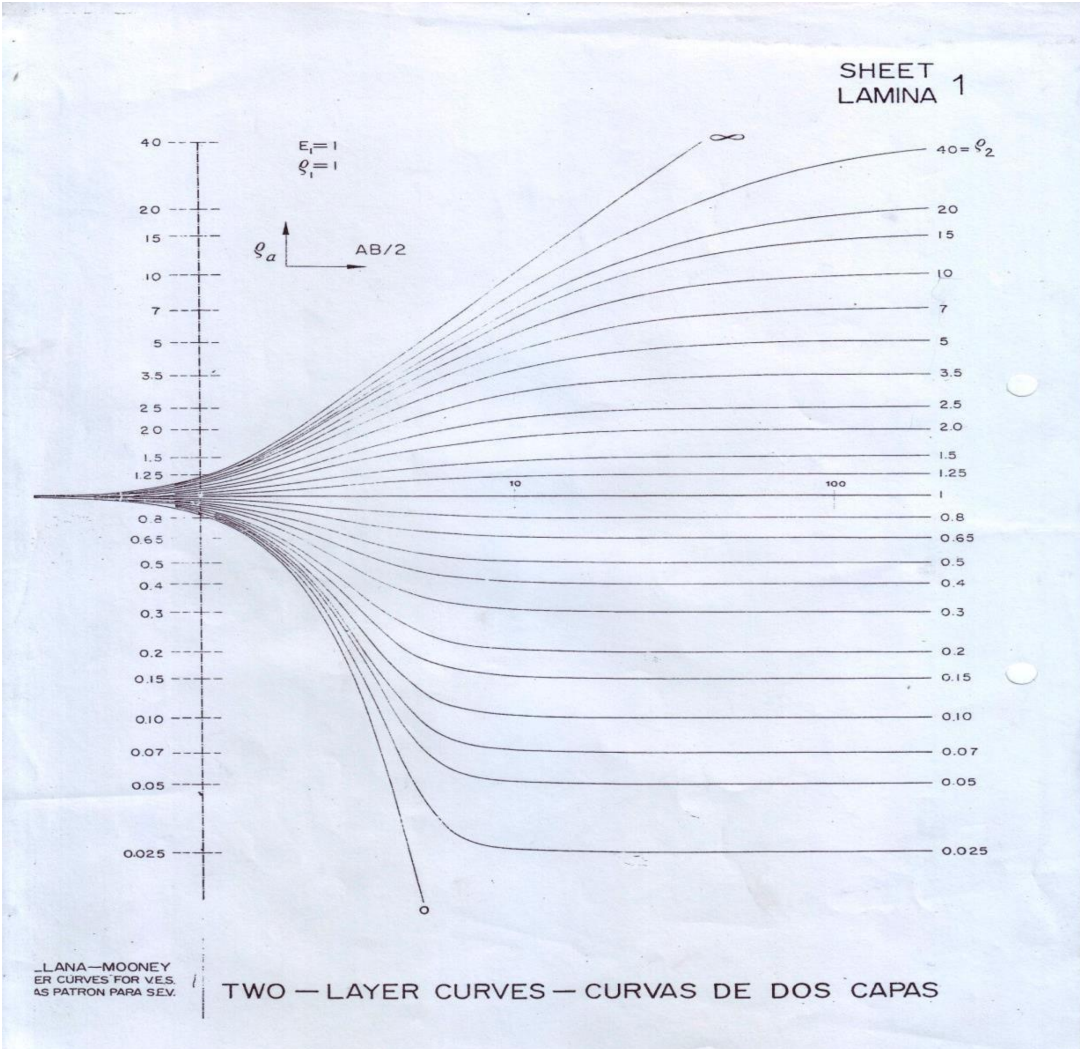


Figure (7): The smoothed VES resistivity curve interpreted manually by using the auxiliary point method.

Generally the partial curve matching by using the auxiliary point method is very common in the manual interpretation of VES curves. The two layer resistivity standard curve of (Orellana and Mooney, 1966), is shown in figure 8.



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The limitations of Resistivity method

Resistivity surveying is an efficient method for delineating shallow layered sequences or vertical discontinuities involving changes of resistivity. It does, however, suffer from a number of limitations:

1. Interpretations are ambiguous. Consequently, independent geophysical and geological controls are necessary to discriminate between valid alternative interpretations of the resistivity data.

2. Interpretation is limited to simple structural configurations. Any deviations from these simple situations may be impossible to interpret.

3. Topography and the effects of near-surface resistivity variations can mask the effects of deeper variations.

4. Depth of penetration of the method is limited by the maximum electrical power that can be introduced into the ground and by the physical difficulties of laying out long lengths of cable. The practical depth limit for most surveys is about 1km (Kearey et.al. 2002).

<u>Resistivity Qualitative Field Techniques</u>

<u>Qualitative interpretation of resistivity method surveying data</u>

1- (VES) curve type interpretations in which depend on the number of subsurface detected layers. The three layers sounding curves represents (A, H, K, and Q) types. Composite Sounding curve types for more than three layers curve types , for example : HKH type for layering resistivity of : $\rho1>\rho2<\rho3>\rho4<\rho5$
2- (VES) Curve type mapping: in this method similar curve types are zoned for a map across the area. This zone provides a primary evidences about the geoelectrical zoning columns under each VES point in the area. One of these maps appears in figure (9).
3- Equi-apparent resistivity surfaces: an iso-apparent resistivity map could be constructed for every Pseudo- depth or Sounding current electrodes

separation (AB\2). Such maps or surfaces may provide a primary vision about the subsurface apparent resistivity variations (figure 10).

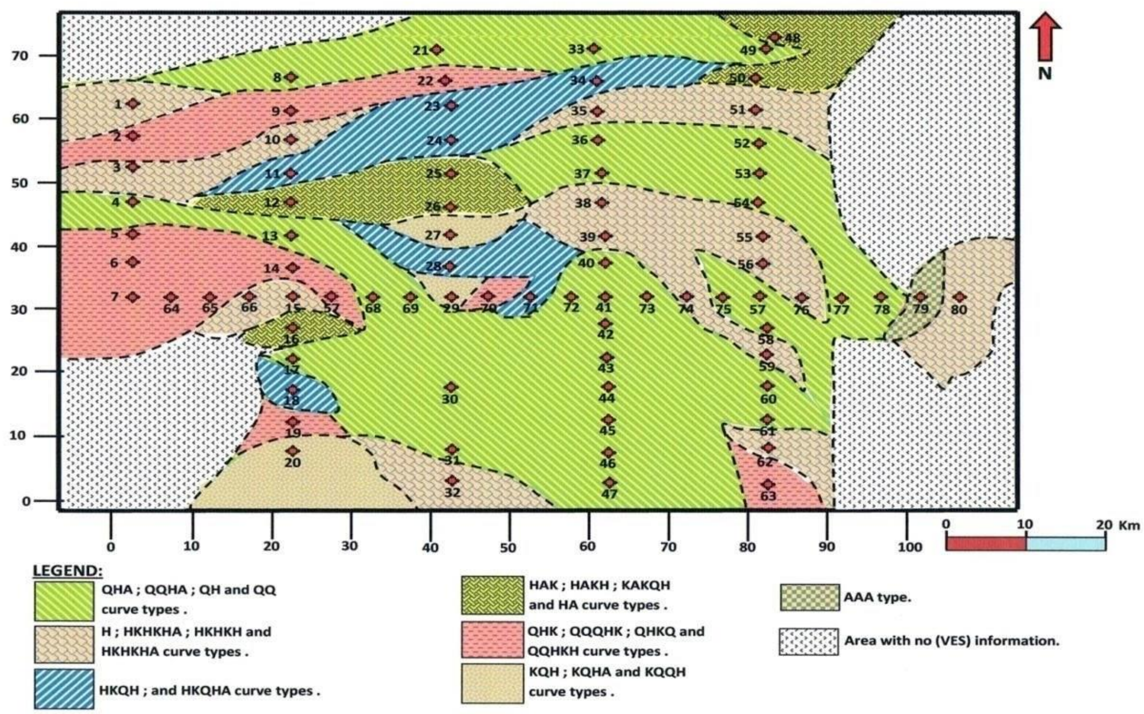


Figure (9): VES Curve types zoning map at South t o Sinjar anticline region \ Iraq , (Al-Khafaji , 2014)

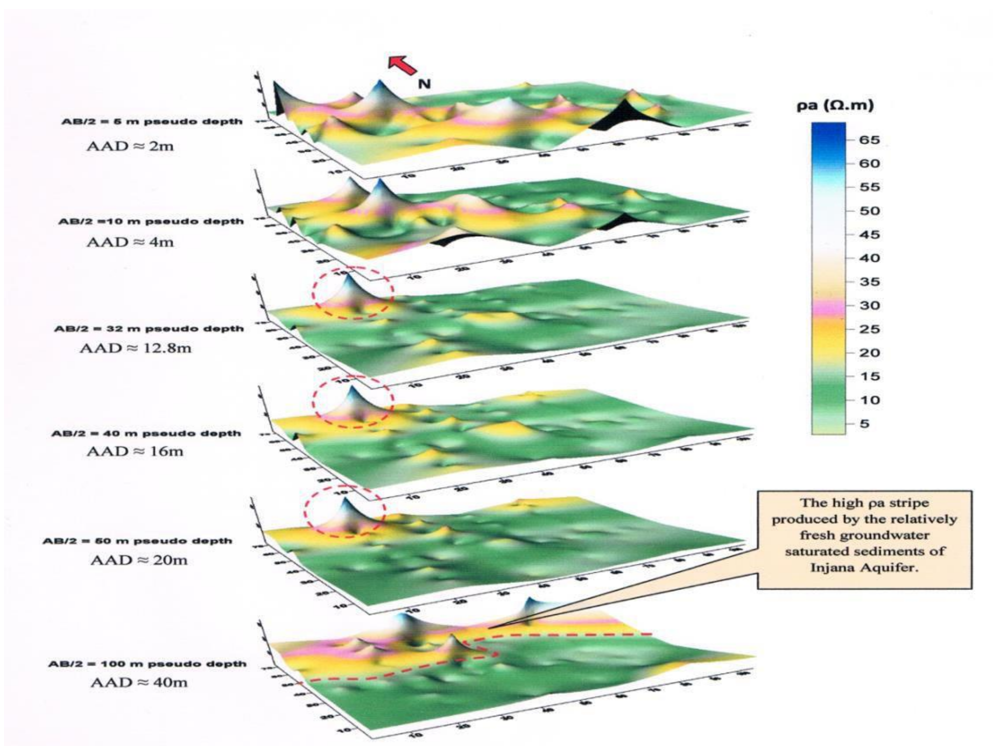


Figure (10): Equi-apparent resistivity maps at South t o Sinjar anticline region \ Iraq , (Al-Khafaji , 2014)

4- Apparent resistivity Pseudo sections: in this type of qualitative interpretation a section is drawn by making the AB/2 spacing as a y- axis and distance between VES points as x-axis. Then the measured apparent resistivity values contoured to visualize lateral and vertical variation of apparent resistivity along the section. In this section the AB/2 spacing considered as a function to the depth, therefore it's not an actual depth, but it represent a pseudo depth, and that's why these sections are called pseudo sections. Figure 11 shows one of these pseudo sections.

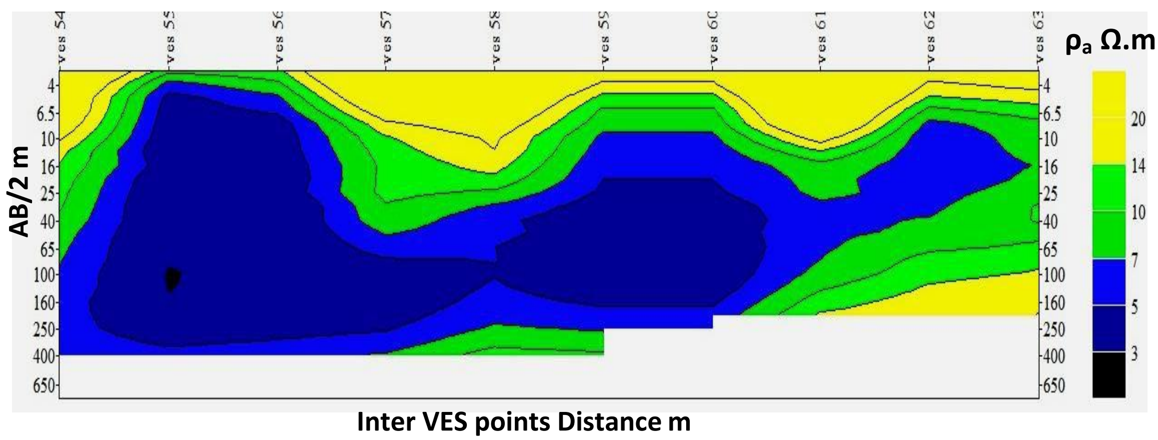
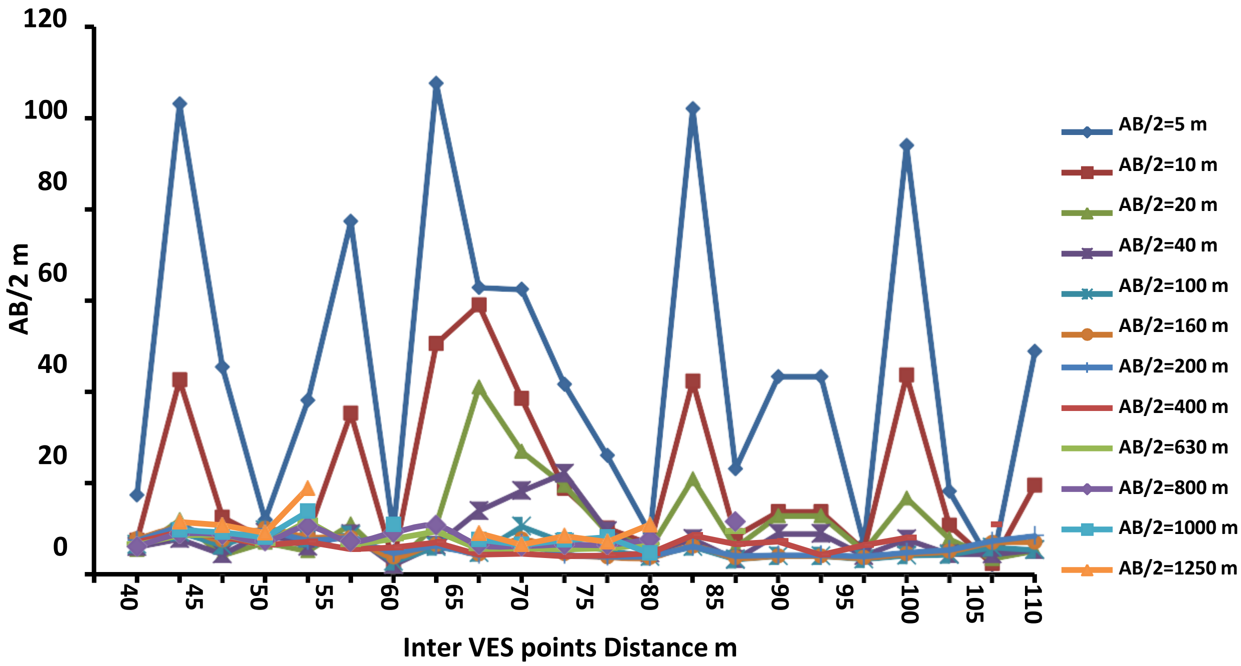


Figure (11): apparent resistivity ρ_a pseudo section along a profile of 10 VES points showing the vertical and horizontal variation according to subsurface lithology.

5- Constant Separation Traversing (CST) and Horizontal electrical Profiling (HEP) for the apparent resistivity data: a plot is drawn between the AB/2 spacing as a y-axis and the inter VES distance as a x-axis , then connecting values of apparent resistivity which belongs to same AB\2 spacing's along the one profile. Figure 12 showing a horizontal electrical profile. This type of profiles used to detect the sudden or abrupt lateral variations of apparent resistivity with pseudo depth which expressed as the AB\2 spacing. The sudden lateral variations in ρ_a are useful in detecting fault locations and near surface lenses like gravel lenses and other lateral variations in lithology facies or clay and groundwater content.



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VES Curve types

The curve type represents a description of how layers change their resistivity values with depth under the array mid point. Therefore , curve type represents a part of the descriptive interpretation. Curve types must be determined for all of the (VES) points in the surveyed area during the manual interpretation. Its important to mention here that the curve type is not important as a descriptive tool only, but it also represents the key that leads the way during the quantitative interpretation, especially if the partial curve matching method with the standard resistivity curves adopted . Figure (12), shows a sample of a smoothed and manually interpretted resistivity curve of (QHA) type.

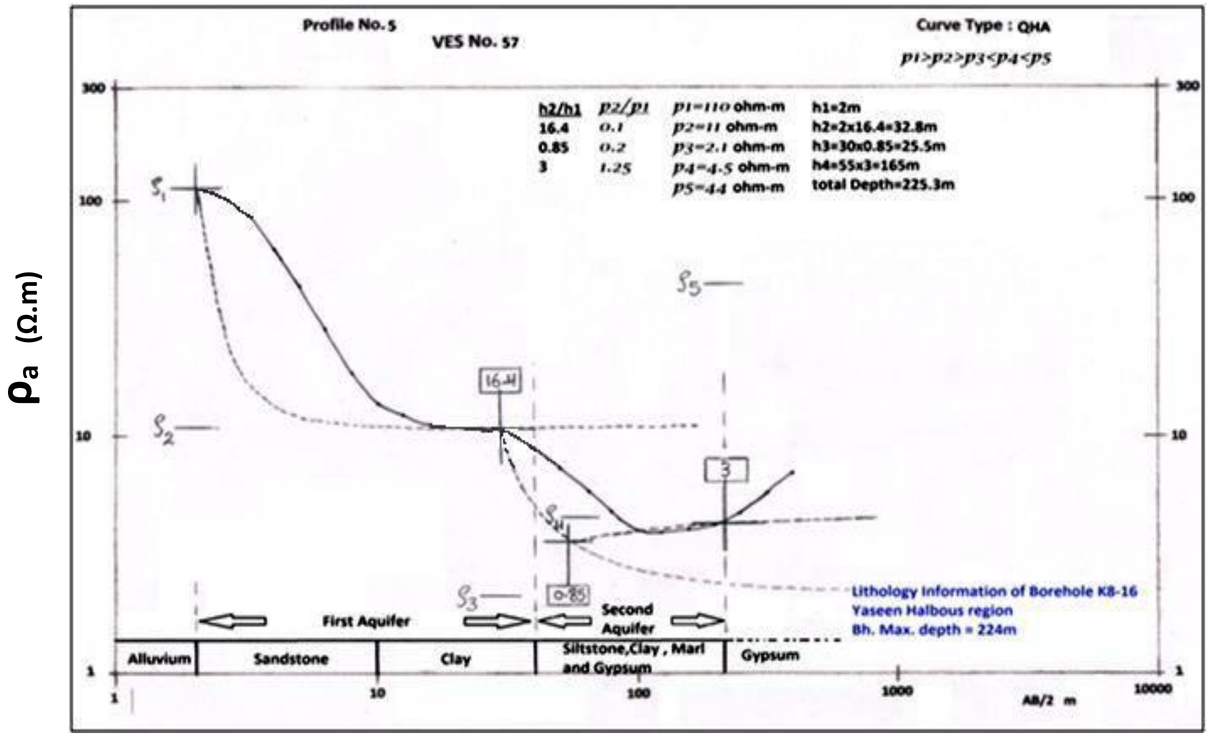

Figure (12): (QHA) resistivity curve type after smoothing drawn and interpreted manually, (Al-Khafaji, 2014).

The whole set of three – layer sounding curves can be devided into four groups, depending on the relative values of ρ_1 , ρ_2 and ρ_3 , (Bhattacharya & Patra , 1968):

1- Minimum type : when $\rho_1 > \rho_2 < \rho_3$. this is also referred as (H-type) (associated with the name of Hummel).
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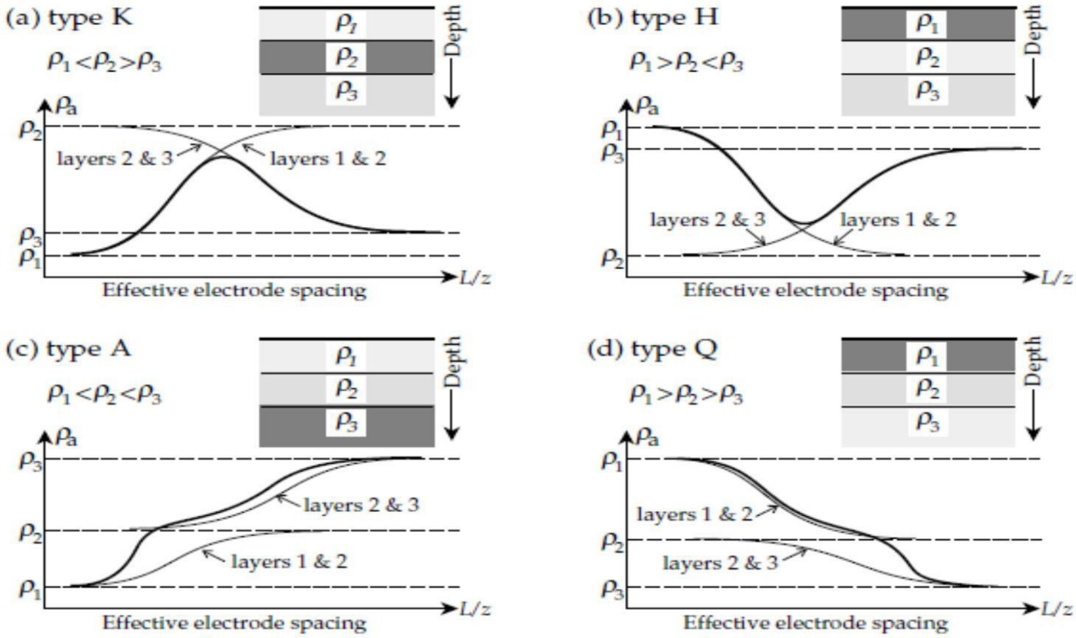
The apparent resistivity curve for a three-layer structure generally has one of four typical shapes, determined by the vertical sequence of resistivities in the layers

(Figure 13). The type K curve rises to a maximum then decreases, indicating that the intermediate layer has higher resistivity than the top and bottom layers. The type H curve shows the opposite effect; it falls to a minimum then increases again due to an intermediate layer that is a better conductor than the top and bottom layers. The type A curve may show some changes in gradient but the apparent resistivity generally increases continuously with increasing electrode separation, indicating that the true resistivities increase with depth from layer to layer. The type Q curve exhibits the opposite effect; it decreases continuously along with a progressive decrease of resistivity with depth. Once the observed resistivity profile has been identified as of K, H, A or Q type, the next step is equivalent to one-dimensional *inversion* of the field data. The technique involves iterative procedures that would be very time-consuming without a fast computer. The method assumes the equations for the theoretical response of a multi-layered ground. Each layer is characterized by its thickness and resistivity, each of which must be determined. A first estimate of these parameters is made for each layer and the predicted curve of apparent resistivity versus electrode spacing is computed.



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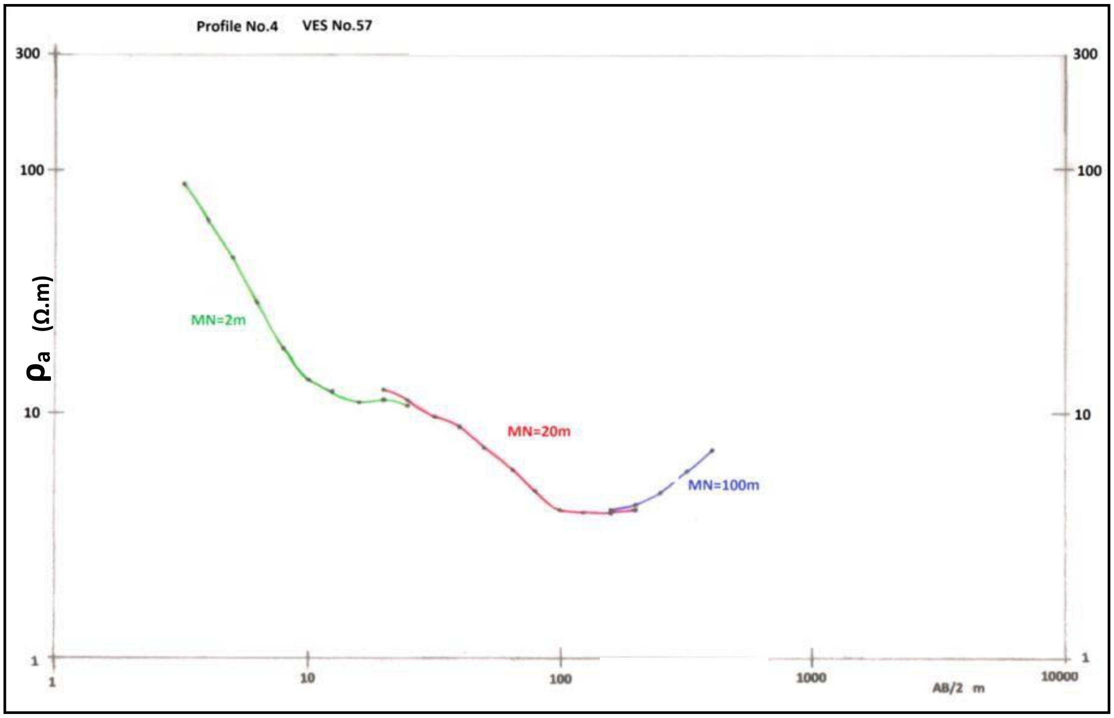

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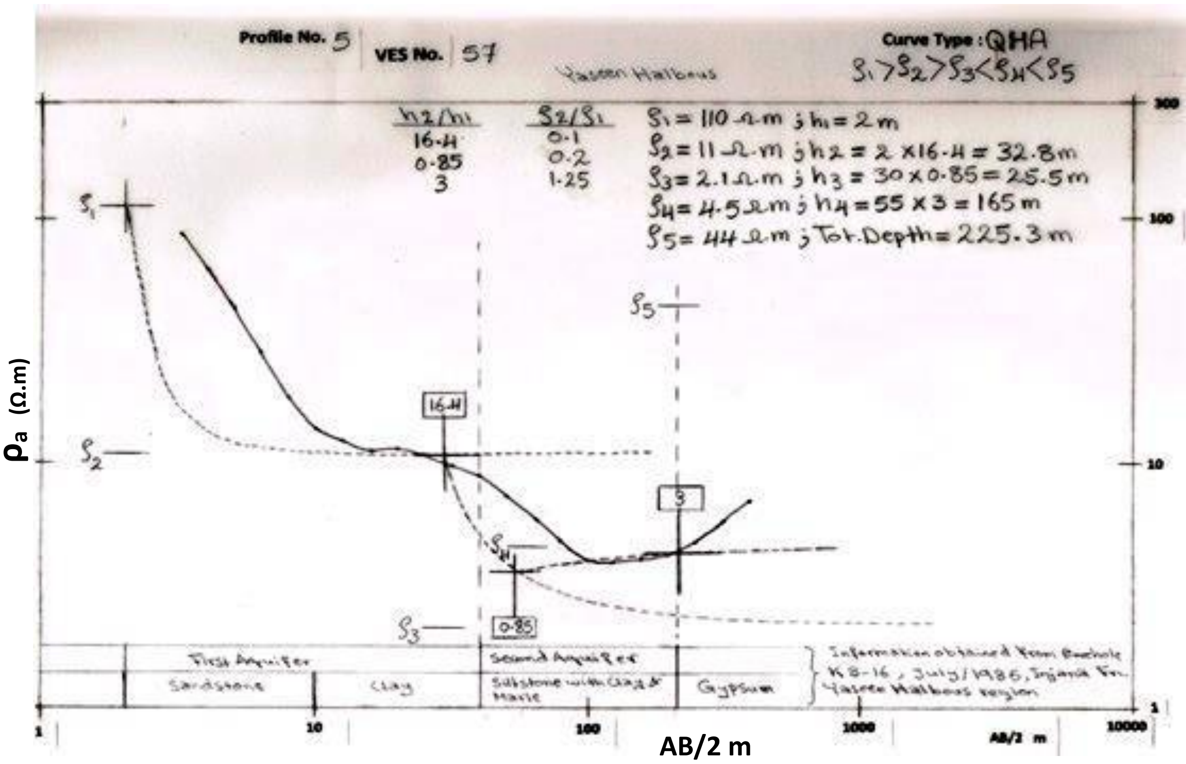

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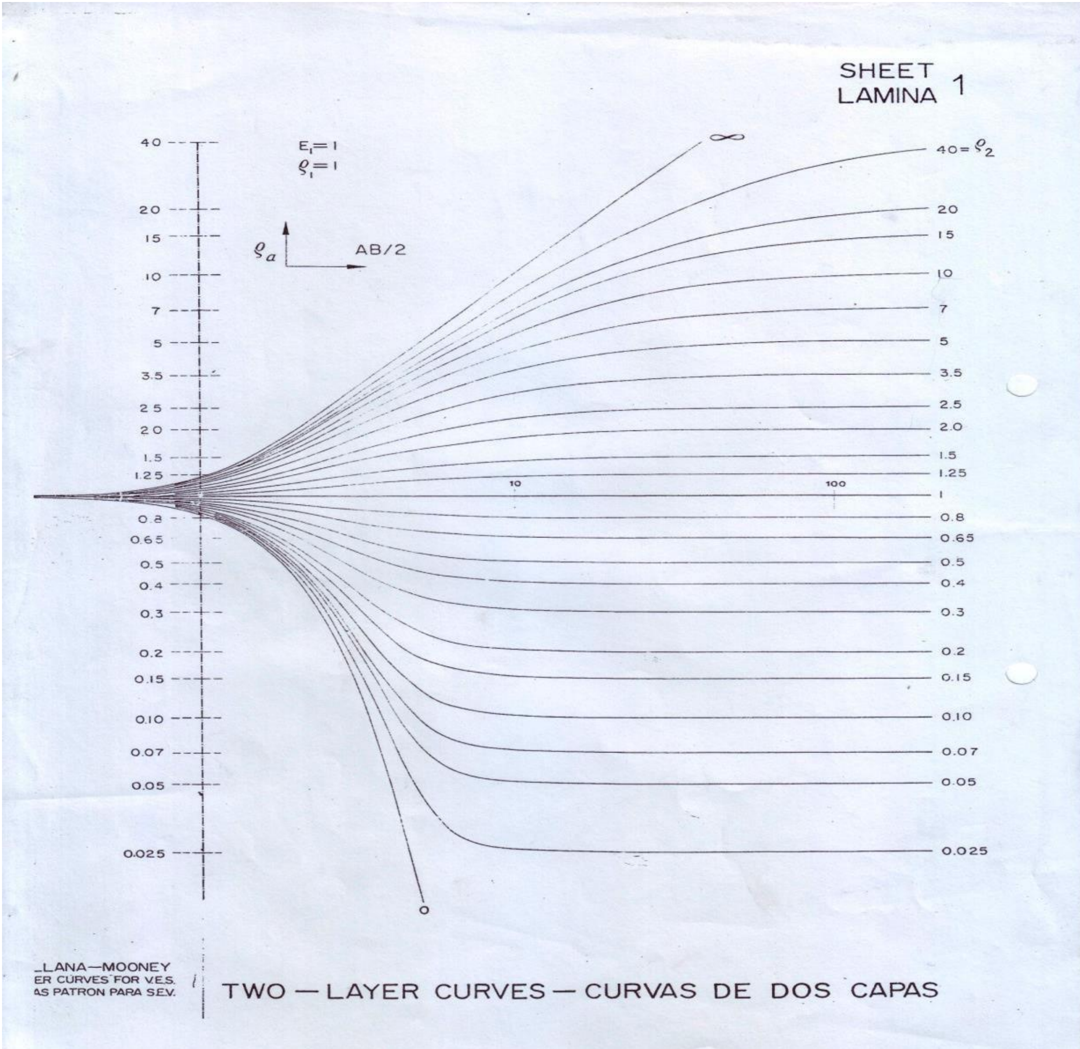

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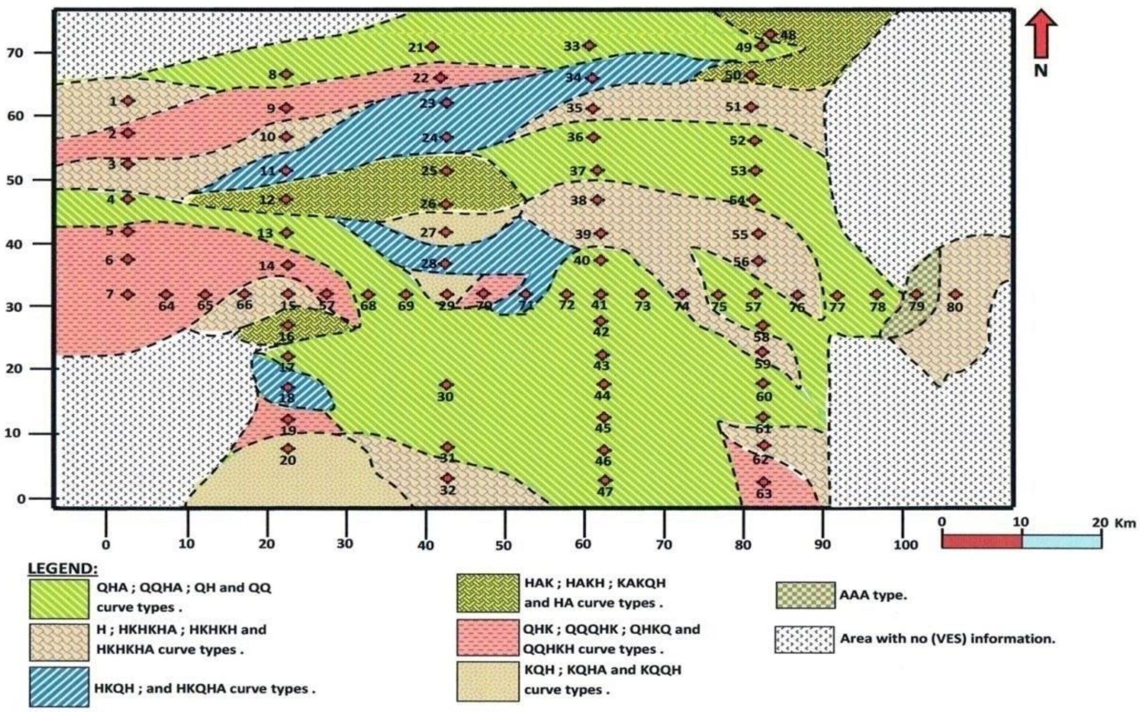

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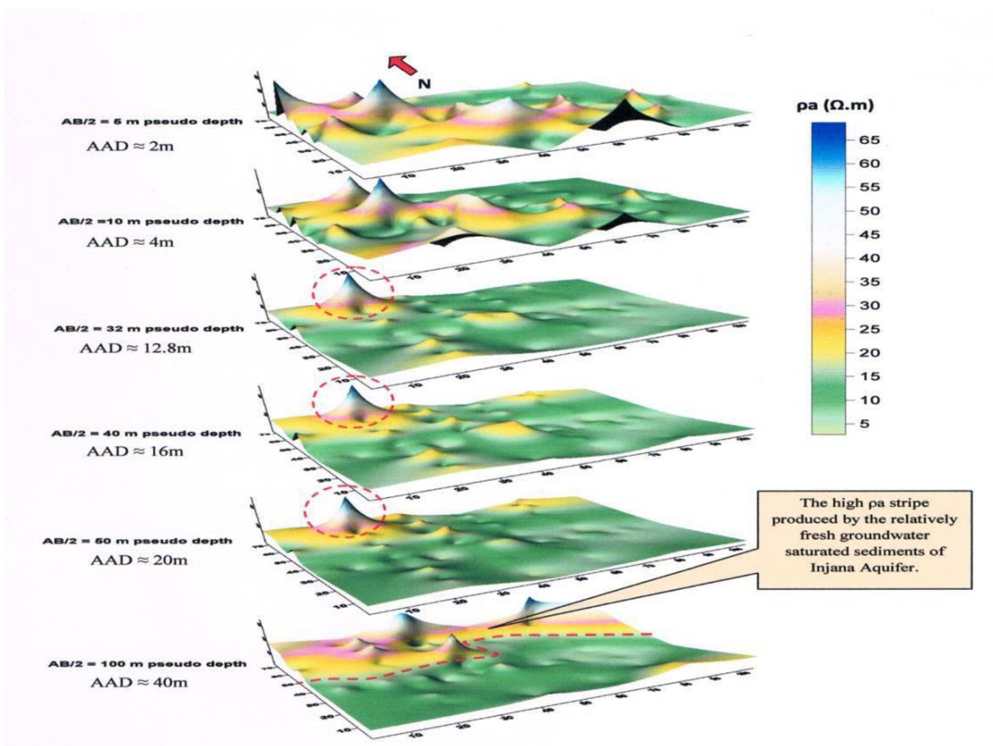

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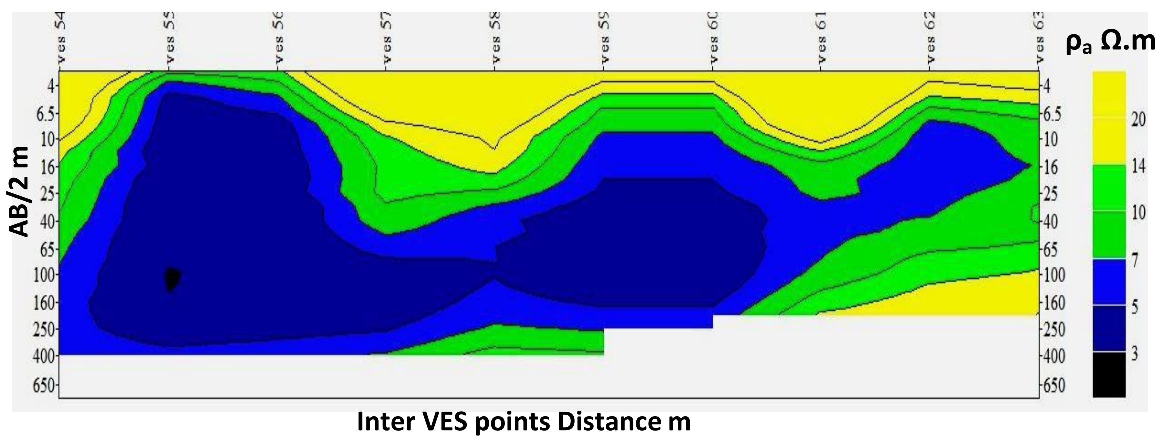

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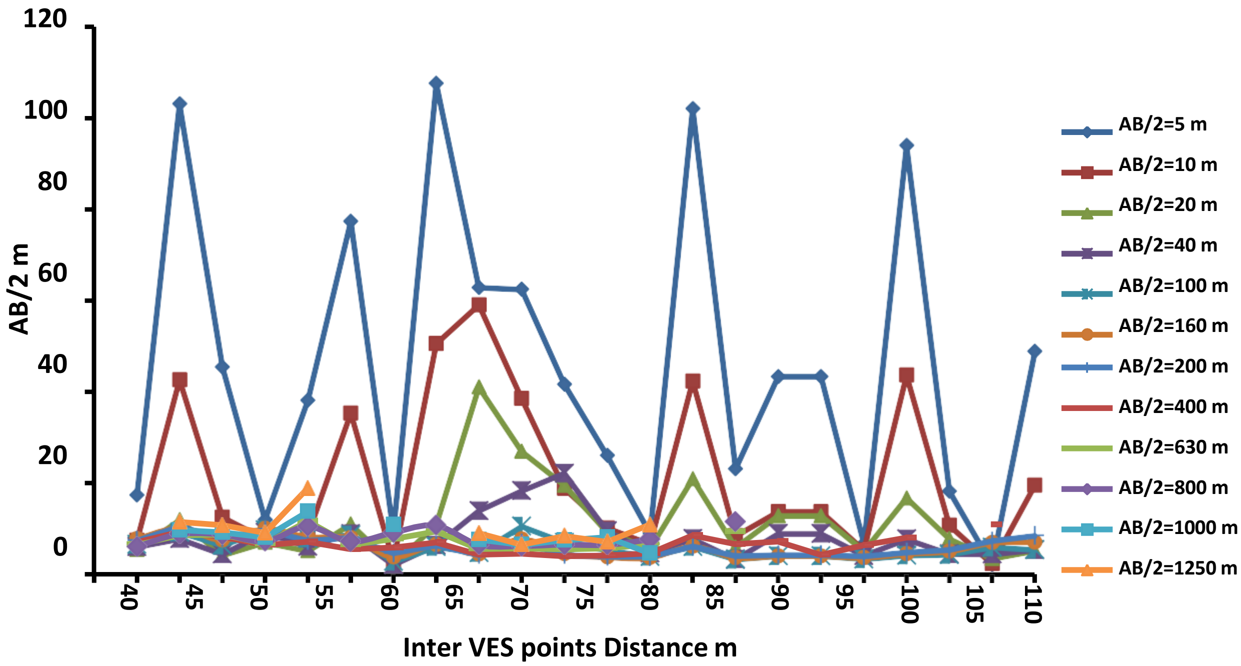

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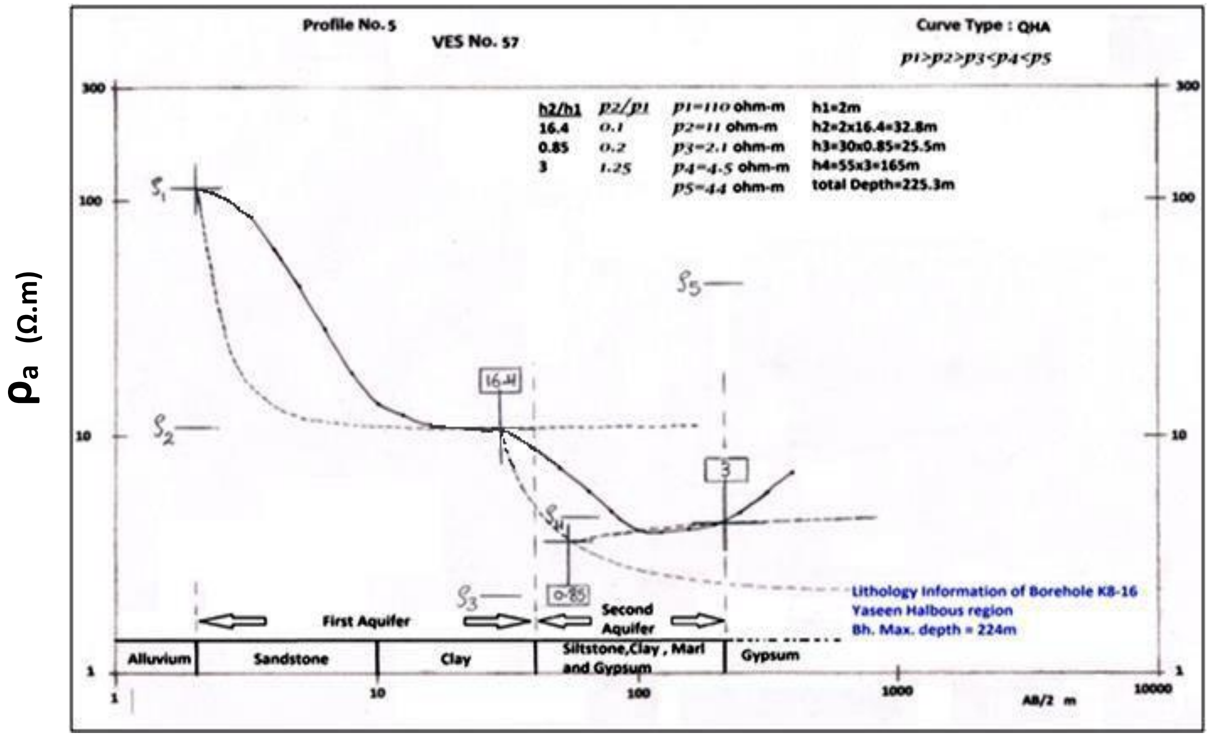

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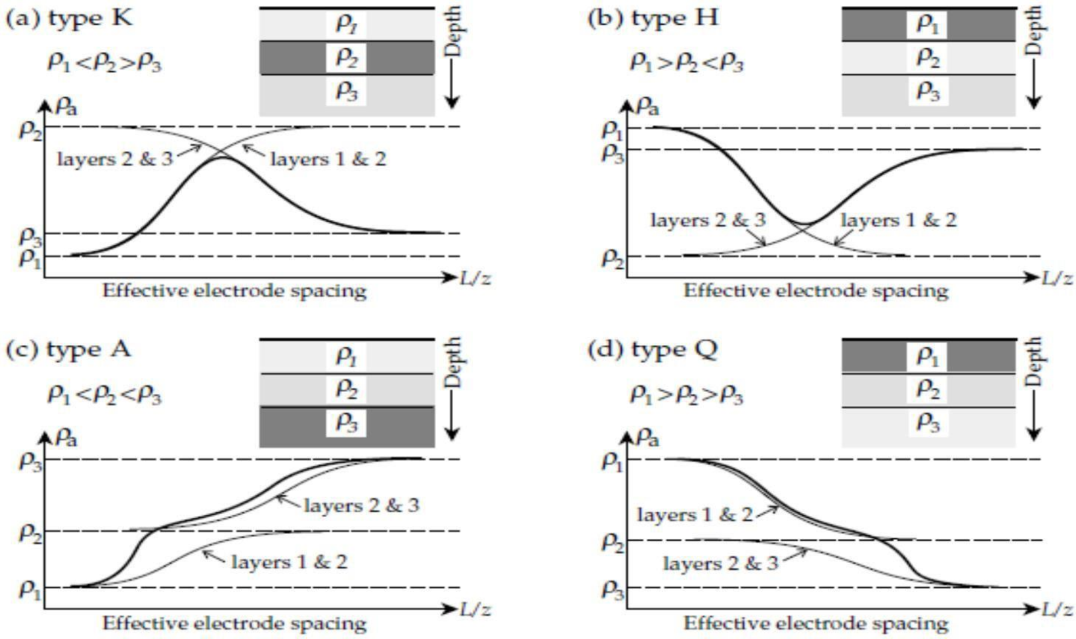

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