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PROCESSING OF GEOELECTRIC CAVITY DETECTION DATA USING DECONVOLUTION FILTERING METHOD

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Summary

Resistivity measurements are widely used to detect cavities. One of the aims of these investigations is to reliably estimate the number and positions of the cavities along the profile. This problem can be solved using a deconvolution filtering method which has been originally developed for archeogeophysical applications.

This paper presents the deconvolution filtering method developed especially for geoelectric cavity exploration. Results of numeric tests prove that using this new method positions of cavities along the profiles can reliably be estimated. Practical efficiency of the method is presented by a field example where the exact positions of five cavities were known along the profile.

Introduction

To detect near-surface cavities is a common task in engineering geophysics. Dimensions and positions of cavities are usually determined by inversion method. If the number of the cavities and their positions along the profile can be determined independently of the applied inversion, the number of the unknown parameters of the inversion procedure will strongly decrease and so their reliability will strongly increase. In some cases the task of the geoelectric measurement is only to mark the drillsites along a profile; then the long inversion process can be substituted by a quick deconvolution filtering method.

Tsokas and Tsourlos (1997) invented deconvolution filtering for geoelectric data which determined the surface projection of near surface inhomogenities. Numerical tests of the new process proved that the method can be used either as a part of an integrated inversion procedure or even as a stand alone process. An interesting field example illustrates the application of this method under complicated geological condition.

Theory

Tsokas and Tsourlos (1997) used deconvolution filters for the first time in geoelectric data processing. They determined the position of an anomaly by a position function D(x), which was calculated after the deconvolution of the measured resistivity values ($\rho(x)$) and a calculated resistivity function ($\rho_0(x)$) describing the anomaly searched for in uniform halfspace (1).

$$\rho(x) * \rho_0^{-1}(x) = D(x) \quad (1)$$

where: $\rho_0(x) * \rho_0^{-1}(x) = \delta(x)$, and $\delta(x)$ is the Dirac function.

The D(x) itself is a $\delta(x-x_1)$ Dirac function where x_1 shows the position of the anomaly.

It is assumed that the measured and the calculated model resistivity curves are quite similar, only their positions are different. Using a model curve centered on the origo, equation (1) can be written as

$$D(x) = \{[\rho_0(x) * \delta(x - x_1)][n(x) * \delta(x - x_0)]\} * \{\rho_0(x) n(x)\}^{-1} \quad (2)$$

where n(x) is a rectangular pulse with the length of $2x_0$ truncating the function $\rho_0(x)$ to definite length.

After Fourier transformation equation (2) can be written as:

$$D(k) = e^{-ikx_1} \frac{R_0(k) * [N(k) e^{-ik(x_0 - x_1)}]}{R_0(k) * N(k)} \quad (3)$$

where k signs the spatial frequency.

The inverse Fourier transform of function D(k) results in the right position of the anomaly only then when the position of the measured anomaly (x_1) lies close to the anomaly described by the calculated model (x_0). In practice x_1 is unknown of course so it is not easy to find a model where $x_1 \approx x_0$ condition is fulfilled. To solve this problem we invented a procedure called "scrolling anomaly". It means that the deconvolution is carried out and D(x) function is calculated using model curves situated at each x point of the profile. Stacking these position functions the result will be a spike exactly over the midpoint of the anomaly or -in case of more anomalies- as many spikes as the number of anomalies marking their right positions.

When deconvolution is applied for cavity detection in nearly 2D medium it is recommended to calculate the $\rho_0(x)$ model function analytically after e.g.:Lösch et al. (1979).

Geoelectric measurements are usually carried out according to a pseudo-section structure where data measured at different electrode separations indicate different penetration depths along the same profile. In such cases the D(x) functions should be calculated for each depth level and finally stacking of these curves will be the result.

Numerical tests

To test the deconvolution filtering method model pseudo-sections calculated by finite difference procedure were used.

Model 1 represents two cavities (size of both: 1m x 1m, distance between the edges: 1 m, thickness of the overburden: 1m), situated really close to each other. A dipole-dipole pseudo section was calculated with a unit electrode spacing of a=1m and n=1,2,...,8 electrode separations. The result of the deconvolution (Figure 2) is a function with two spikes marking exactly the midpoints of the cavities proving the very good resolution capability of the procedure.

Other model calculations were carried out representing difficult geological conditions and in each case the cavities were correctly traced.

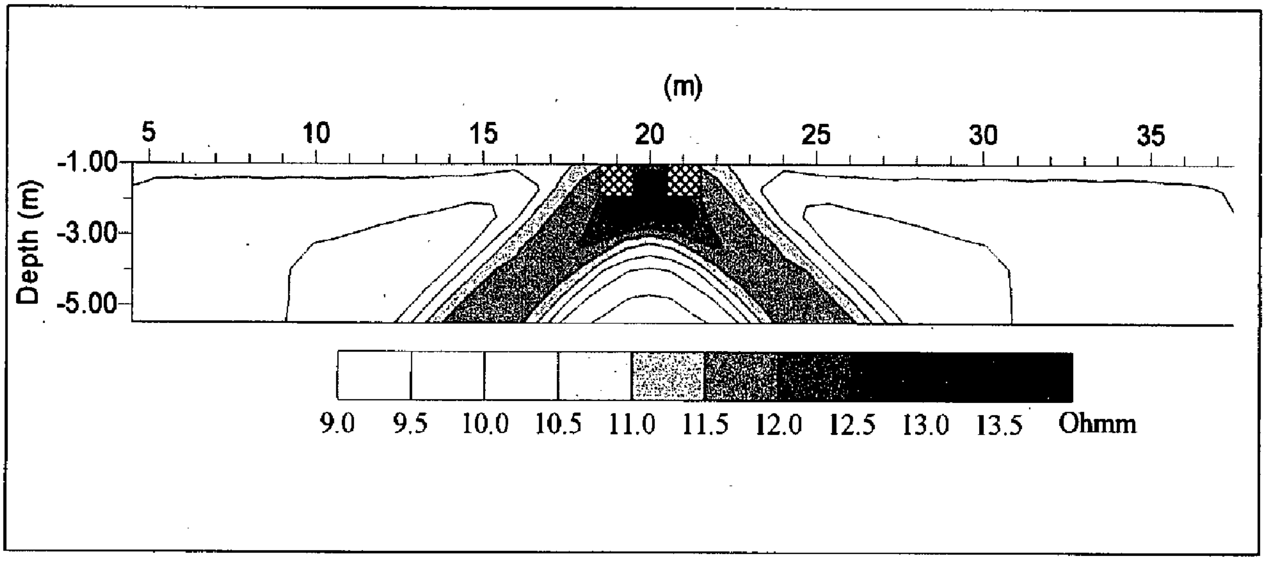

Figure 1

FD model pseudo-section with two targets marked with ⊠

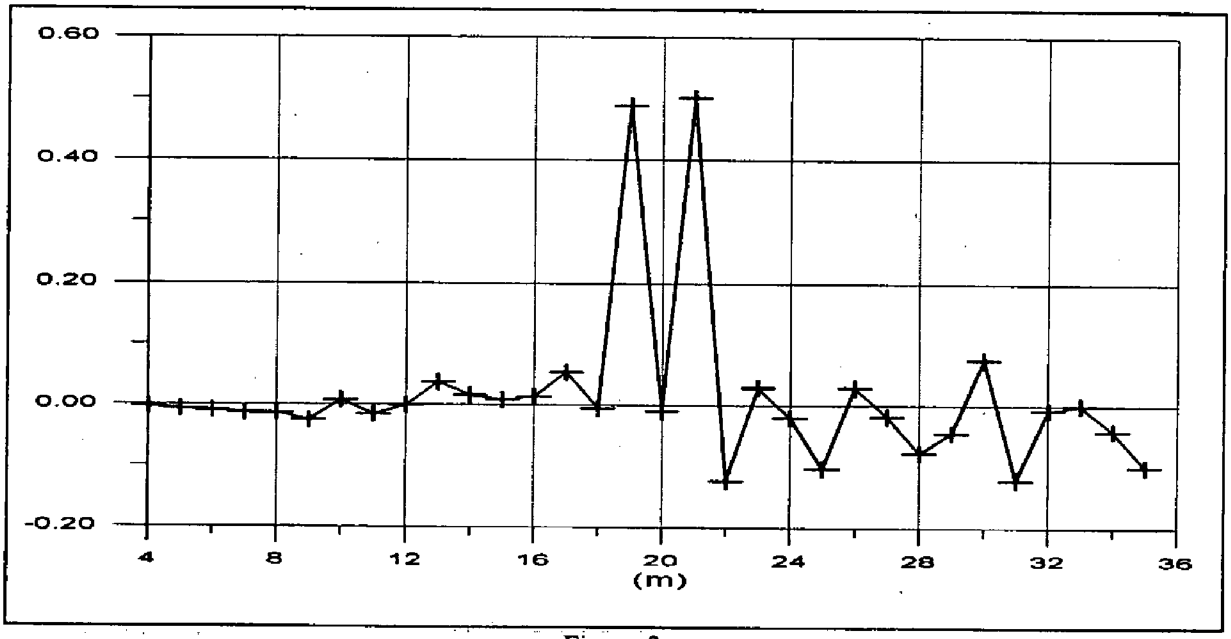

Figure 2

Stacked position function calcultated for Model 1

Case history

A 60 m long geoelectric profile was measured in the village of Egerszólát in Northen Hungary. Objective of the measurement was to detect cavities which could endanger the vehicles using the road. As a result of investigations sites for drilling had to be given.

A dipole-dipole measurement was carried out using a multi-electrode system and a Diapir10R equipment. The unit electrode distance was a=1 m, and n=1,2,..,6 levels were measured (Figure 3). To process the data a cross-correlation function was used in order to eliminate the noise and other geological effects from our data. Result of the processing is a position function (Figure 4) with five maximums indicating the midpoints of the cavity anomalies. Upon this function the drillpoints could be marked. A seismic profile was also measured in the area and its results showed good correlation with the geoelectric data.

References

LÖSCH W., Militzer H., Rösler R. 1979.: Zur geophysikalischen Hohlraumortung mittels geoelektrischer Widerstandmethoden. Freiberger Forschungshefte C341 Leipzig

TSOKAS G. N., TSOURLOS P. I. 1997: A least-sqares approach to depth anomalies from archeological sites by inversion filtering. Geophysics **62**, 1, 36-43

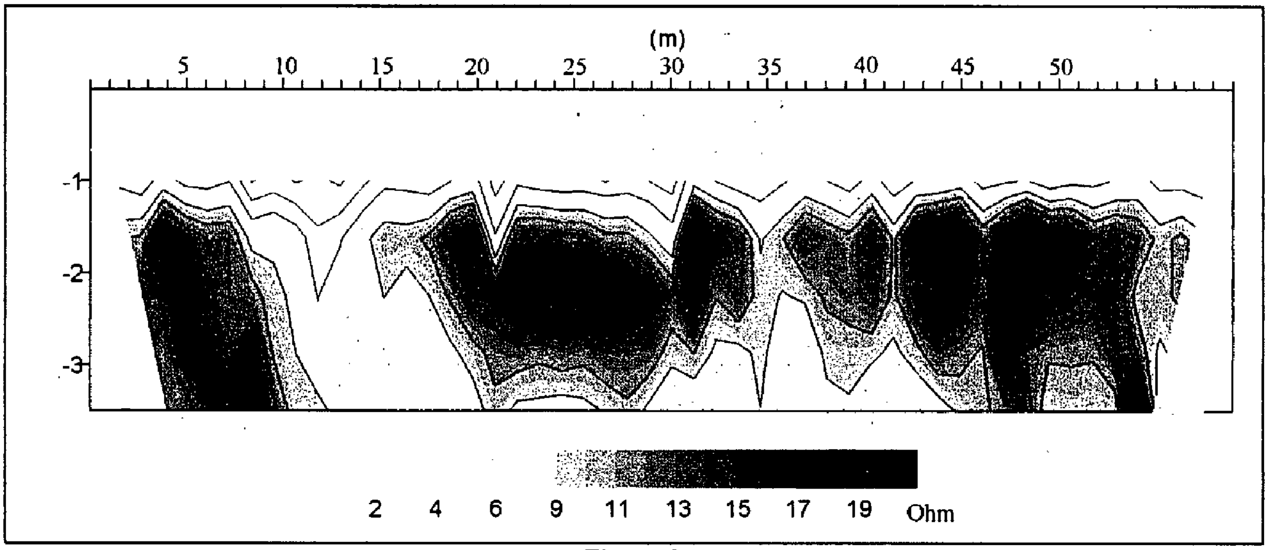

Figure 3

Measured resistivity pseudo section

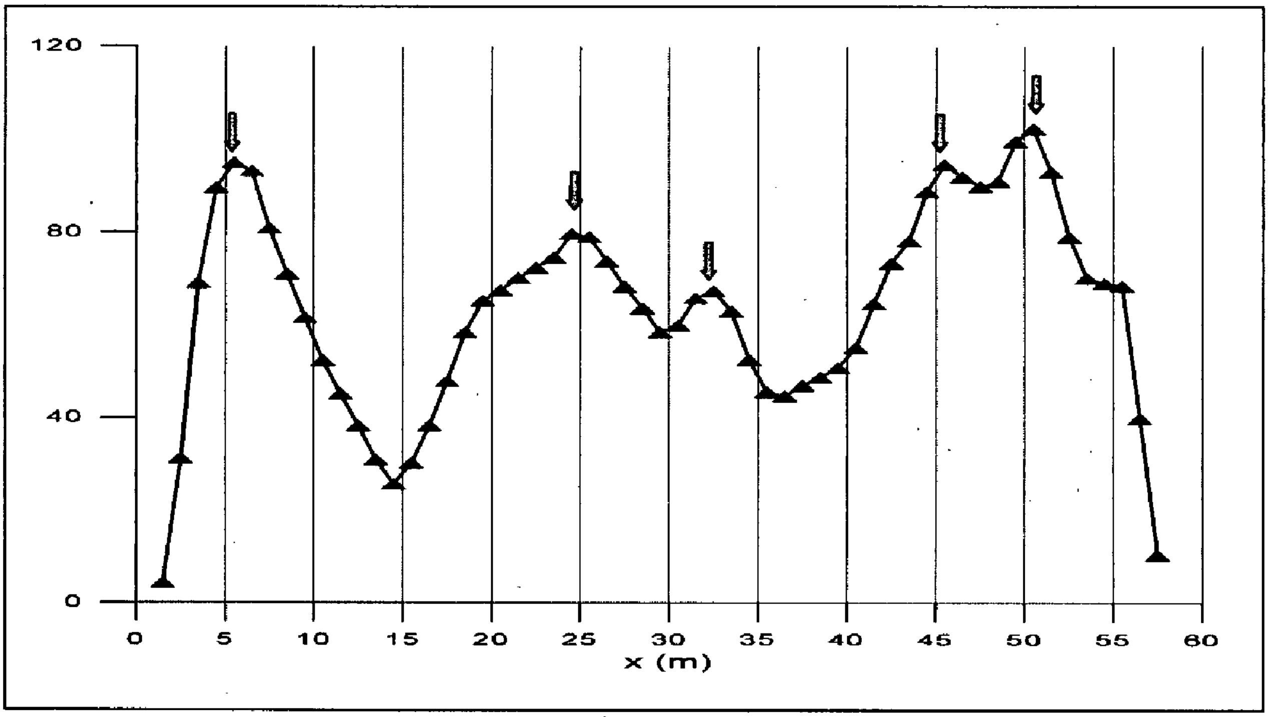

Figure 4

Position function with five maximums marked with