P095 PROBLEMS OF DETECTING BURIED 3D OBJECTS WITH 2D GEOELECTRIC PROFILING METHODS

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Abstract

Detection of near-surface buried objects is usually carried out along one or more survey lines and processed by 2D algorithms. Problems appear if the target is three-dimensional. The sensitivity for the 3D effects near the profile strongly depends on the configuration of the electrodes, the three-dimensional object situated under the survey line is also mapped differently to the 2D plane. The indications of 3D objects on a 2D-resistivity section are specific for each electrode configuration.

Theoretical calculations simulating 2D geoelectrical surveys above 3D objects have been carried out in order to examine this problem in the cases of four different electrode arrays (pole-pole, dipole-dipole, equatorial dipole, Wenner alpha). The results of the modeling processes made it possible to rank the examined arrays from the point of sensitivity for 3D effects and quality of imaging the object.

Test measurements have been carried out in order to prove the conclusions of the theoretical investigations. Two perpendicular survey lines have been measured above a buried cellar using dipole-dipole, pole-pole and Wenner arrays. The 2D pseudosections were compared with the results of GPR and 3D geoelectric measurements.

Introduction

Detecting near-surface cavities is a classical task in engineer geophysics. Investigating buried two- and three-dimensional objects using geoelectric profiling methods is well documented. However real three dimensional surveys are rarely used in practice, usually measurements are carried out along one or more parallel lines (seldom along a grid) which means that the 3D object is investigated by 2D or quasi 3D (when 2D measurements are processed by 3D algorithm) methods.

The aim of this work was to examine some widely and effectively used 2D electrode configurations in cases of detecting 3D objects and to show the main interpretation problems applying 2D processing algorithm.

Model calculations

The first step of the model calculations was to determine the resistivity sections of two different 3D shapes in the cases of the examined electrode arrays using a FE modeling method. Then data for 2D pseudosections were collected along specific lines acting as the results of profile measurements. The 2D resistivity sections were processed with the algorithm of Loke and Barker (1996). At last the qualification and ranking of the examined arrays were done.

The resistivity sections of two different models have been calculated. The first target (Model 1) was a symmetrical prism imaging a buried shaft or well (Figure 1a), the second one (Model 2) imaged a real cellar of L shape with an entrance on the surface (Figure 1b). Both non-conductive objects were placed in uniform conductive halfspace with the resistivity contrast of 100 Ohmm.

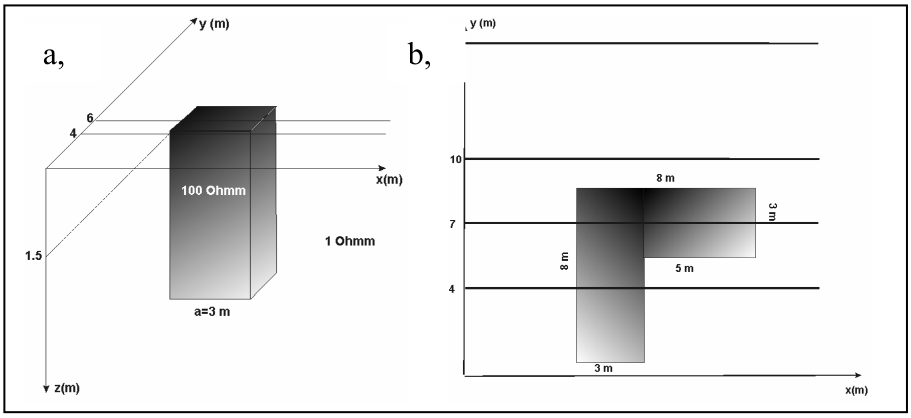

Figure 1. *3D models and positions of 2D survey lines. a: Vertical prism model. b Horizontal projection of a cellar model. Maximal height 2.5 m, maximal thickness of the cover 1.6 m*

The 2D resistivity sections were created for widely used electrode arrays: dipole-dipole, pole-pole, equatorial dipole, Wenner.

Three aspects of the qualification were the studied.

1) *Accuracy of the 2D model substituting the 3D target*: RMS difference of input (result of 3D model calculations) and output (result of 2D inversion) datasets.
2) *Accuracy of imaging:* comparison the shape of the resistivity anomalies of the 2D section after the inversion and the projection of the target to the plane of the survey.
3) *Sensitivity for distortions of 3D effects coming out of the plane of the survey line:* RMS difference of the inverted pseudosection and the uniform halfspace.

Two survey lines were placed in the case of Model 1. The first one was at edge of the object (y=4 m), the second one above the middle of the model (y=6 m) where the conditions are closest to the real 2D effect (Figure 1a). The investigated electrode arrays were qualified after Aspect 1 and Aspect 2.

Ranking the electrode configurations was carried out all of the aspects in the case of Model 2. Aspect 1 was examined along the survey line above the dipping entrance (y=4 m). The imaging (Aspect 2) was determined at y=7 m where the plane projection of the target was two-dimensional, but there have been strong 3D effects out of the plane of the survey line. The sensitivity for outer 3D effects (Aspect 3) was investigated on the bases pseudosections away from the target (y=10 m and y=15 m). The locations of the survey lines are shown in (Figure 1b).

Field test

A field work gave us an opportunity to test some conclusions of the theoretical calculations. The task was to locate a buried air-filled, cellar with wall covering. The horizontal extensions of the object were determined by 100 MHz GPR measurements along parallel survey lines.

Then the grid of electrodes with distance of 1 m covered the area above the cellar and a 3D geoelectric measurement was carried out (Figure 2). After data processing the dimensions and location of the buried cellar could be determined: length 12 m, width 5 m, height 3.3 m, thickness of cover layer 2.5 m.

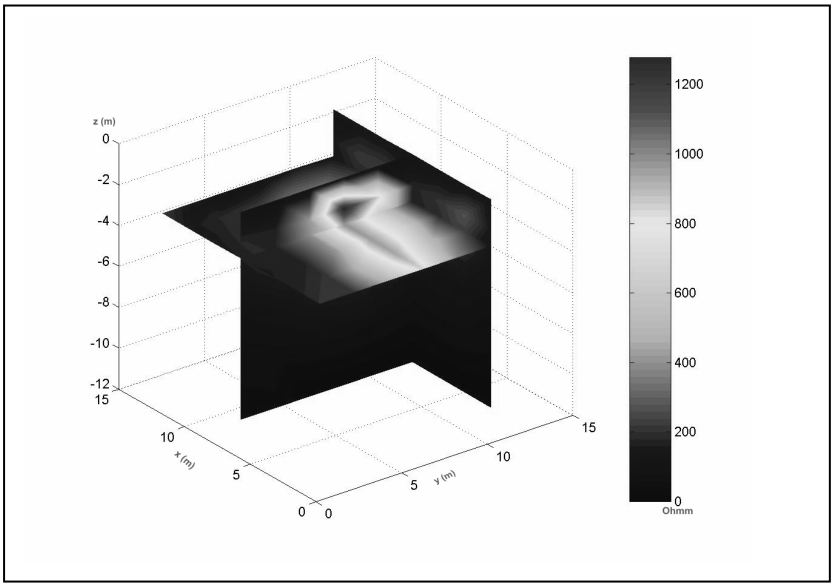

Figure 2. *3D resistivity section of a buried cellar.*

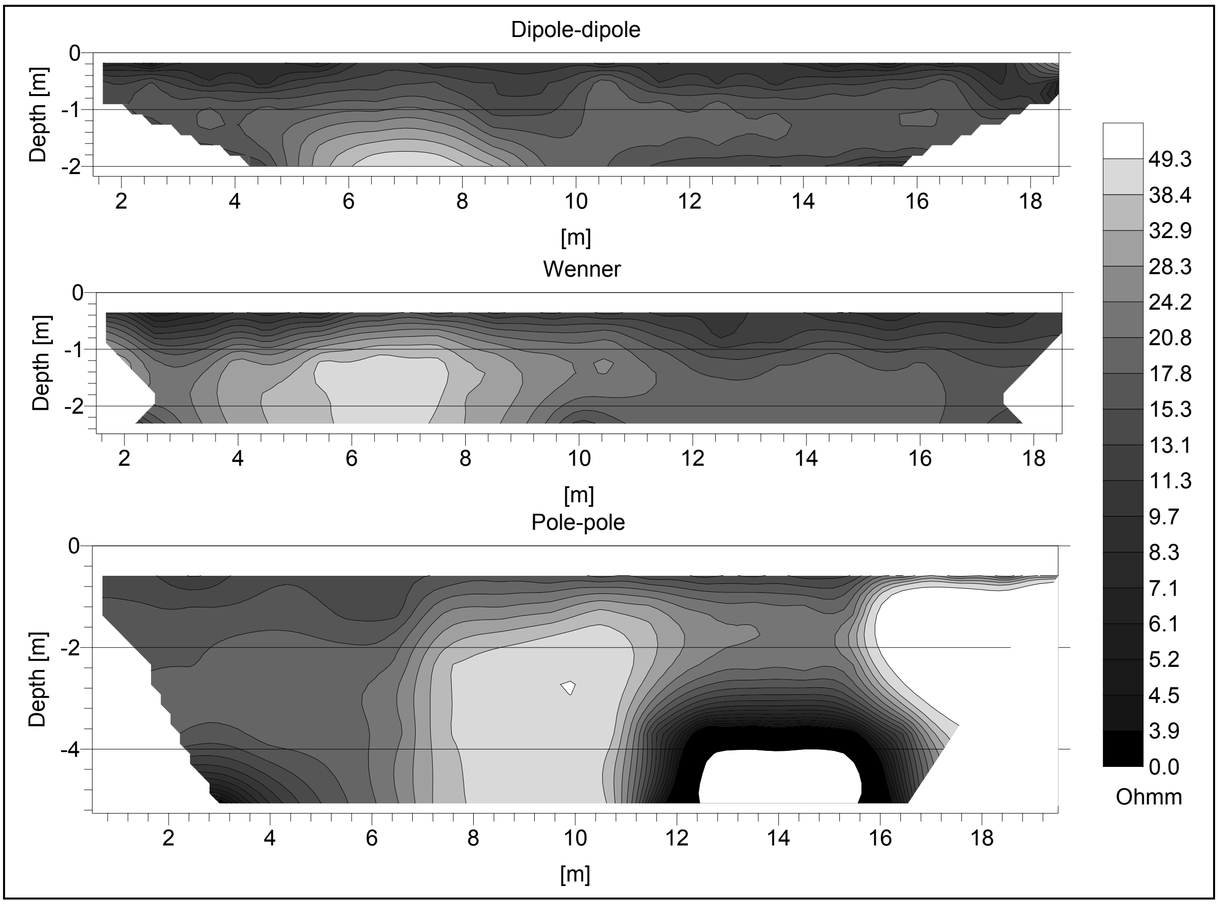

Figure 3. *2D resistivity pseudosections measured above a buried cellar. The survey lines are perpendicular to the length axis of the object.*

Two perpendicular test survey lines were measured using three configurations (pole-pole, dipole-dipole, Wenner, unit electrode distance 1 m) parallel and perpendicular to the length axis of cellar. The target can be reliably interpreted only on the cross sections. The most remarkable resistivity anomaly appeared on the pole-pole and Wenner sections but the effect of the cellar can be detected on the dipole section as well (Figure 3). Only after measuring the perpendicular survey line can be suspected that the detected object is three-dimensional.

After the end of the geophysical investigations the cellar was excavated and it was proved that the results of the data interpretation imaged well the reality.

Conclusions

The model calculations have shown that investigating 3D objects with 2D geoelectric method causes different problems in the cases of different electrode arrays. Applying pole-pole or Wenner configuration is advisable in order to reduce the error of dimensions. It is strongly advised to avoid the use of equatorial dipole array.

The presence of a 3D object in the vicinity of the survey line causes the highest error at equatorial dipole array. This configuration can be applied when signals of a nearby 3D target are searched for. The decrease of the 3D effect as the function of distance is strongest at Wenner array (Figure 4.).

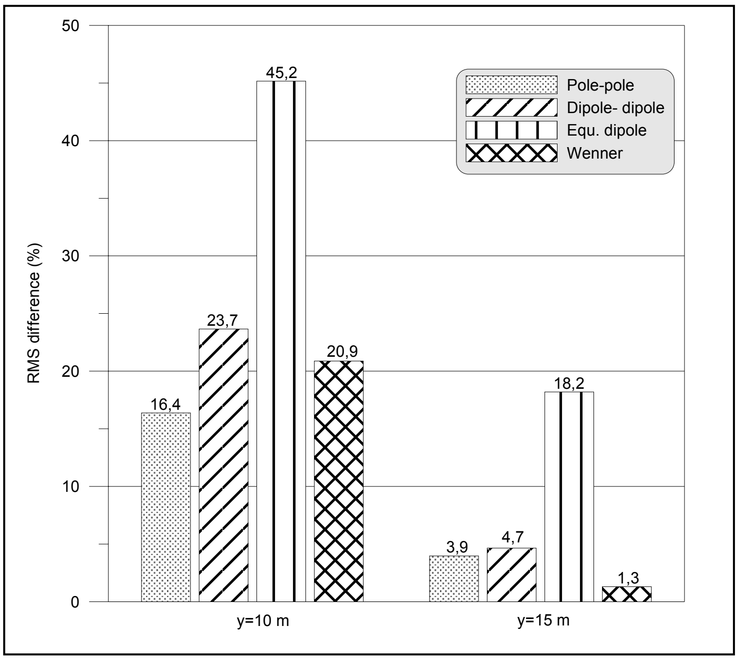

Figure 4 *Difference from the uniform halfspace caused by a 3D object outside the survey plane in distances of y=10 m and y=15 m.*

References

Loke M. H. and Barker R.D., 1996, Rapid Least squares inversions of apparent resistivity pseudosections by a quasi-Newton method, Geophysical Prospecting 44, 499-523.