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Contamination detection

Detection of hydrocarbon contamination with 3-D resistivity and IP method

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A consortium with three partners from different fields of environmental sciences (geophysics, hydrogeology, geotechnics) was formed for a three year long project to improve hydrogeophysical methods in order to detect and characterize special subsurface contaminants. Four different contaminated sites were chosen in Hungary as study areas to improve and calibrate special geophysical methods to provide remediation experts and hydrogeologists with necessary information for reliable transport modelling. A strong collaboration between the geophysicists and hydrogeologists evolved protocols and techniques to carry out successful site assessment and remediation schemes of contaminated lands.

This study presents the geophysical results on one of these test sites containing creosote contamination. High resolution 3-D geoelectrical measurements were applied in order to give reliable information for site diagnostics.

Keywords: remediation, geoelectrics, transport modelling

1. Introduction

Since all geological structures are 3-D in nature, a full 3-D resistivity survey using a 3-D interpretation model should give the most accurate results. At the present time 3-D data acquisition and inversion techniques for DC resistivity and IP surveys have experienced a rapid development over the past years. However it has not reached the level where, like 2-D surveys, it is routinely used. The main reason is that the survey cost is comparatively higher for a 3-D survey. There are two current developments that should make 3-D surveys a more cost-effective option in the near future. One is the development of multi-channel resistivity meters that enables more than one reading to be taken at a single time. This is important to reduce the survey time. The second development is faster microcompu-

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ters to enable the inversion of very large data sets to be completed within a reasonable time.

2. Background and site description

The field experiment was carried out at a former site of the Hungarian Railway Company. Watertight of poles and ties was carried out by creosote on this site until 1985. Coal tar creosote is a thick, oily liquid typically amber to black in colour. Virtually all wooden railroad ties and telephone poles in use are treated with creosote to retard rotting. Long-term exposure to low levels of creosote, especially direct contact with the skin during wood treatment or manufacture of coal tar creosote-treated products has resulted in skin cancer and cancer of the scrotum.

The location is illustrated in *Fig. 1.* There are many buildings and pavements, which complicates the survey planning and spreading. An eight-channel AGI SuperSting R8 resistivity and IP instrument was used for data collection. This equipment produced a relatively fast data acquisition. Command files were generated for 24 hours periods, and were uploaded to the control unit every morning. 252 electrodes were set to the surface and electrode strings were located into two boreholes (*Fig. 2*). More than 45 000 measurements were carried out during four days in a wide spread of electrode configuration (bipole–bipole, radial dipole–dipole, gradient) and location (surface–surface, borehole–surface and borehole–borehole).

3. Data processing and inversion

Due to the common data acquisition of resistivity and chargeability data with the same electrode configuration a special data filter was used to improve the signal/noise ratio. Generally, upper and lower limits of resistivity and chargeability data can be determined for all measurements. However, in this case a crossplot of the apparent resistivity and IP data was used to check data quality. *Figure 3* shows this crossplot of the raw measured dataset in log–log scale. The aggregations of measurement points are emphasized with a thick broken line. Reject data outside this area improved the first iteration of inversion.

Fig. 1. Location of the contaminated site
1. ábra. A mérési helyszín

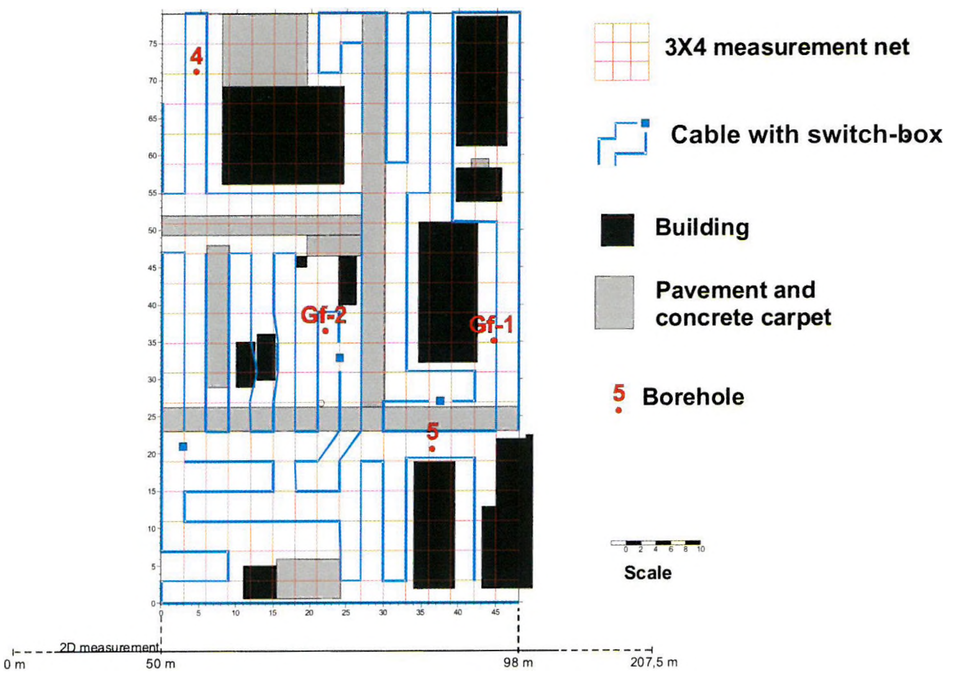

Fig. 2. 3-D spread of the electrodes on the site

2. ábra. A 3D mérés terítési vázlata

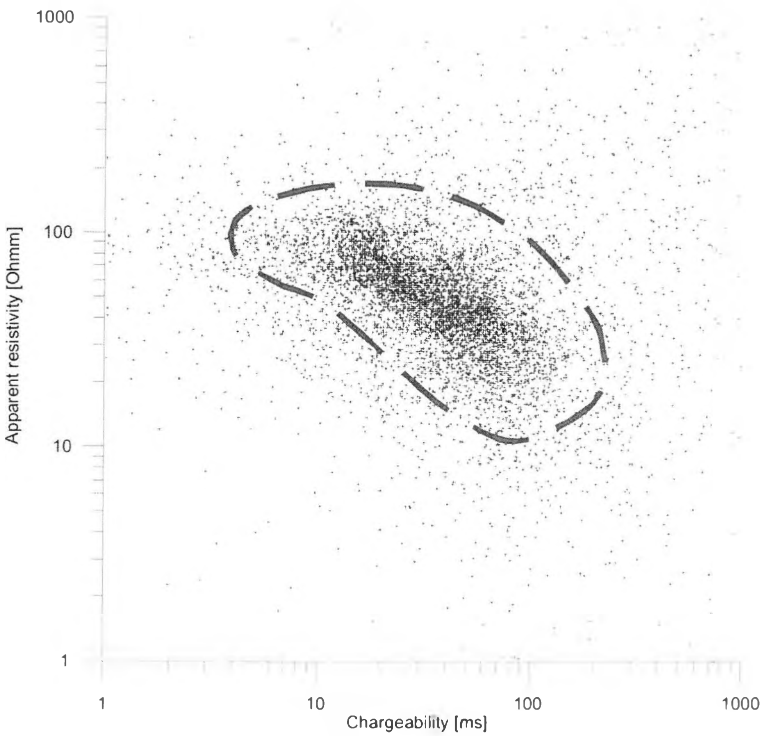

Fig. 3. Crossplot of the corresponding apparent resistivity and chargeability data in log–log scale

3. ábra. Az összetartozó ellenállás és tölthetőség adatok keresztdiagramja log–log léptékben

Common inversion of resistivity and IP data were carried out with the Res3-DInv software [LOKE 1996–2004].

4. Discussion and conclusions

The measurement mapped two separated contamination plums. The contamination has lower resistivity and higher chargeability compared to the surrounding mainly sandy aquifer. *Figure 4* illustrates the smaller plum with vertical slices in the approximate direction of groundwater flow. The direction of groundwater flow is south–north and the level is signed on the sections with a white continuous line.

The corresponding slices show similar events, but the chargeability result has a more realistic result. Characteristic layer boundary can be seen at the depth of three meters. This layer mobilized the contamination to south, while the groundwater elongated it to north direction. The creosote used for water-tight of wooden utilities is stored above this plum. This fact explains this structure. Results are checked by analysis of borehole samples.

Acknowledgement

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Szénhidrogén szennyeződés kimutatása 3D ellenállás és gerjesztett polarizációs (GP) módszerrel

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Uniós pályázat keretében fejlesztéseket végeztünk különböző típusú szennyeződések kimutatására. Ennek keretében 3D geoelektromos méréseket végeztünk kőszénkátránnyal szennyezett területen. A kőszénkátránynak igen magas (> 50%) poliaromás szénhidrogén tartalma van, mely erősen karcinogén hatású. A területen 252 darab elektródát helyeztünk el. A mérések több napon keresztül történtek és az adatok feldolgozása is több hetet vett igénybe.

A cikk tartalmaz egy ellenállás/tölthetőség diagramot, mely az összetartozó nyers mérési adatokat mutatja log–log léptékben. Az inverzió után kapott ellenállás képen is látható a szennyeződés térbeli helyzete, azonban a GP módszer sokkal karakteresebb, és a háttéradatokkal is egybevágó adatokat szolgáltatott. A kapott eredményábrákon látszik az a réteghatár, mely horizontálisan mobilizálta a szennyeződést, látszik annak útvonala a talajvízszintig, és kimutatható, hogy a talajvíz mekkora mértékben mobilizálta azt.

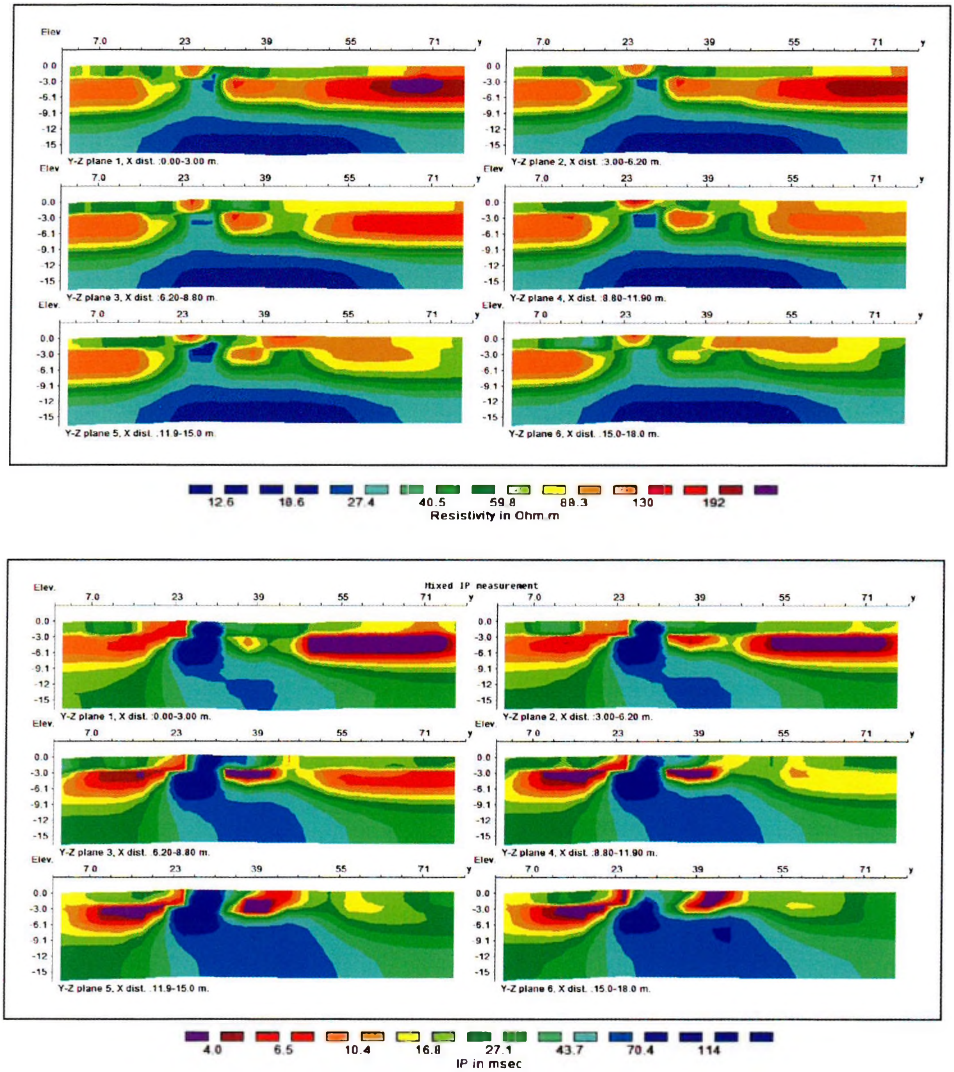

Fig. 4. Inverted resistivity and chargeability slices of the plum

4. ábra. Az inverzióval kapott fajlagos ellenállás és tölthetőség szelvények a csóva vonalában