Repeatability of Geoelectrical Investigations

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Introduction

The use of geophysical methods, especially geoelectrical investigations, in observations of e.g. saltwater intrusion or leakage from waste deposits, has increased during the last years (Stierman, 1984; Chapman & Bair, 1992; Frohlich et. al., 1994). In the field of monitoring in time, however, this use have not been fully implemented, due to i.a. lack of knowledge of how the results from the geoelectrical resistivity investigations varies during the year and from year to year.

Within a larger project, investigating the surroundings of a waste deposit, the repeatability of resistivity measurements has been examined as one objective. The investigation area is situated in Småland, South Sweden and is rather complex and heterogeneous, with assorted sandy and gravely soil layers. There is also possible till layers on top of the bedrock which is found at a depth of approximately 15 metres beneath the soil surface.

This paper presents some of the results from these investigations and give a short discussion of the impacts from natural variations on the measuring results.

Method

The method used in this investigation is direct current resistivity profiling. It results in a profile which will show the lateral distribution of apparent resistivities in the ground. Electrical resistivity is the reciprocal value to electrical conductivity and hence, we will be able to detect areas with different electrical properties.

Since dissolved chloride ions in the ground water increases the electrical conductivity, dc-resistivity methods have proven to be suitable to detect areas with raised chloride content, as for instance, leachate plumes at waste deposits or salt water intrusion in coastal areas.

However, the natural variations, both in time and space, can be in the same magnitude as the anthropogene anomalies and by that conceal the expected results of anthropogene effects. In this investigation the aim is to compare the natural variation of resisitivity by time in the same profile under different climatic circumstances during the year (summer and autumn) and from year to year.

The repetition of the measurements has been ongoing twice a year since June 1994. The occasions when the measurements has taken place are:

- 1994-06-07
- 1994-10-07
- 1995-06-26
- 1995-09-16

The topical profile was measured with an electrode configuration according to Wenner (Fig. 1) with a constant electrode separation (a) of 20 m (Kofoed, 1979). The whole array was moved forward in 20 metres steps. This configuration then enables us to measure the apparent resistivity within a depth of approximately 10 m (Barker, 1989) and every 20 metre.

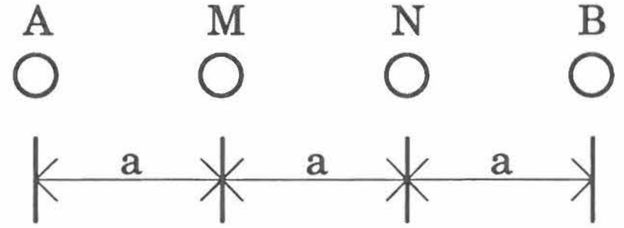

Figure 1. *The Wenner electrode configuration.*

A current (I) is put into the ground by the two outer electrodes, A and B. Then the potential gradient (U) is measured between the two inner electrodes, M and N. The formula

$$\rho_\alpha = 2 \cdot \Pi \cdot a \cdot \frac{U}{I}$$

will give the apparent resistivity (ρ_α) in a half sphere volume of the ground with the centre at the mid point of the electrode array.

Results

The repeatability of the DC-resistivity profile is, as seen, good (Fig. 2). The shape of the different parts in the profile is fairly well repeated from one year to another. However, there is a quite clear difference between the measurements made during the summer (dotted line) compared to those made in the autumn (solid line). The latter have been shifted toward higher resistivities by approximately 225 Ohm-m. It is also possible to distinguish between the years. In 1994, the mean upshift was 160 Ohm-m, while in 1995, the mean upshift was 280 Ohm-m.

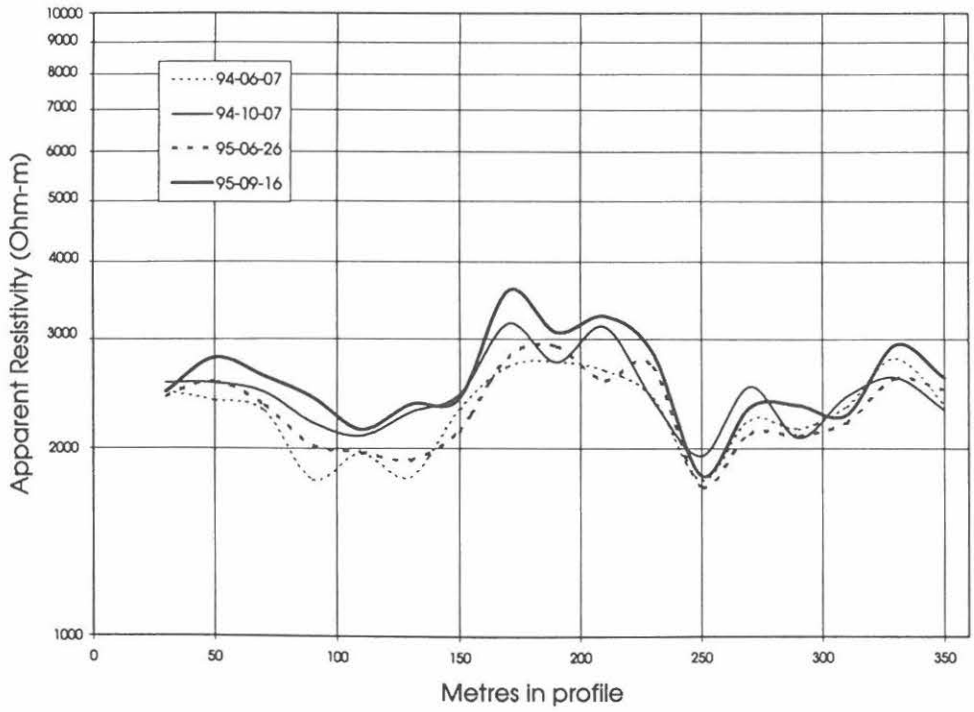

Figure 2. *Results from the investigated profile.*

The differences between the seasons and between the years are undoubtedly an effect of different ground water levels and soil moisture content within the measured volumes. In the autumn investigation the result of a dry summer season is reflected, when the measurments where done before the intense autumn rain started. The lower resisistivity values in summer, on the other hand, still reflects the foregoing spring with snowmelt and higher groundwater levels.

The variations in the apparent resisitivity which gives the general shape of the profile, is mainly due to the distances to the ground water level in different parts of the profile. This makes the resisitivty values clearly reflect the topography of the investigated profile.

By taking these variations between seasons and even years into account the dc-resistivity profiling method would be an easily manageable reconnaissance tool in mapping and monitoring ground water contamination, as for instance increased chloride content.

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