P28

Effect of Positional Inaccuracies on Multielectrode Results

S. Szalai (Hungarian Academy of Sciences), A. Koppán* (Hungarian Academy of Sciences) & L. Szarka (Hungarian Academy of Sciences)

SUMMARY

We have started to investigate the consequences of various noises o the interpreted results for various multielectrode arrays. We expect, it will be possible to find out, what kinds of noise have the most effect on the resulting data. Such an investigation may lead to a better elimination of potential errors due to noises. In the first step (presented in this paper) we studied the appearance of false anomalies due to positioning errors of the electrodes. In realistic field conditions, in spite of the greatest possible care, the electrode positions contain some inaccuracy: either in case of dense undergrowth, or varied topography, or very rocky field. In all these cases, it is not possible to put the electrodes in their theoretical position. As a consequence, the position data will contain some error. The extent of such inaccuracies was exactly determined by using a laser distance meter. Then, we computed their effect on the resulting apparent- and inverted resistivity data. We carried out such a study for Wenner, Wenner-beta, pole-dipole and pole-pole arrays. In the light of our conclusions, the usual assumption about random noise seems to be an oversimplification.

INTRODUCTION

The multielectrode measurements are influenced by various noises, depending on the array geometry. Realising the popularity of multielectrode measurements, and an oversimplification tendency in the handling of various noises, we have found as an actual task to investigate consequences of noises on the interpretation. From such an investigation we expect to find out the effect of various noises on the resulting data. We also expect a better knowledge about the risks of potential errors due to noises. Furthermore, some elimination possibilities of such noises are expected, too.

A number of factors would be worth studying, including for example (1) effect of the switching order of the electrodes, (2) effect of the electrode, which is put hypothetically in infinity, (3) effect of the difference between the real and hypothetic directions of the strike, and also (4) deviation of the actual physical model from the two-dimensionality.

In this paper, as a first step, we present, what pseudo-anomalies arise due to positioning errors of the electrodes. In realistic field conditions, in spite of the greatest possible care, the electrode positions do contain some inaccuracy: especially in case of dense undergrowth and varied topography. It these cases, it is not possible to put the electrodes in their theoretical position. As a consequence, the position data will be distorted. The situation is even more annoying in case of surface rockiness, where you easily identify the theoretical position of the electrodes, but it might not possible to put the electrodes there.

The extent of such inaccuracies was exactly determined by using a laser distance meter. Then, we computed the effects on the resulting data. We carried out such experiments for Wenner-α, Wenner-β, pole-dipole and pole-pole arrays.

The results show that the positioning errors can be kept small even in case of very uncomforatable field conditions, if near-surface rocks are not present. In case of very rocky surface the distortions are more serious, but it is still possible to make some correction.

MEASUREMENTS

In various field conditions (various undergrowth density, high-frequency topographic variation, various surface rockiness) we set out the measuring profile, then we determined – by means of a laser distance meter – the exact $\mathbf{r}=\{x,y\}$ position of the electrodes. (See Figure 1, where x is parallel to the profile, y is perpendicular to it.) Using the real position of the electrodes, we computed the corresponding apparent resistivity values on the surface of a hypothetic half-space of 100 ohmm, by applying the geometrical factor of the ideal situation. Then the computed apparent resistivity data were inverted. (All these steps are steps of the normal procedure. The inversion was carried out by using the AGI Earth Imager 2D software.) Such computations were carried out for Wenner-α (Wa), Wenner-β (Wb), pole-dipole (PDP) and pole-pole (PP) arrays, and a distance of 1 m was applied between the neighbouring electrodes. In Figure 2 the inverted pseudosections of Wa and Wb arrays are shown.

The measurements were carried out along four measuring profiles. P1 was an ideal measuring line; P2 and P3 are characterised by less (P2) or more (P3) dense undergrowth and/or varied topography; P4 was nearly ideal from the point of view of undergrowth and topography, but its surface rockiness was very high.

Where the rockiness was relatively low, the arithmetic mean of $|\mathbf{r}_{ideal}-\mathbf{r}_{real}|$ was only 12-13 mm, that is 1.2-1.3 p.c. of the electrode distance of 1 m, while $|\mathbf{r}_{ideal}-\mathbf{r}_{real}|_{max}$ was 8 cm. These geometric inaccuracies may lead to higher false anomalies than 10 p.c. in the near-surface region, but they drastically diminish with depth. At the depth of 1/3 part of the depth of investigation, the intensity of false anomalies becomes less than 2 p.c. (Larger values than 2 p.c. were obtained only in case of the Wenner-β array.)

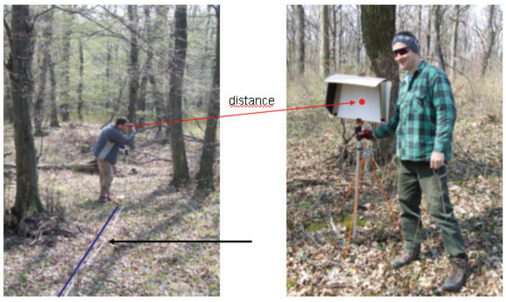

Figure 1: *Determination of the electrode positions by means of laser distance meter along the measuring line P2 (note the tortuosity of the tape-measure, due to the bumpy surface)*

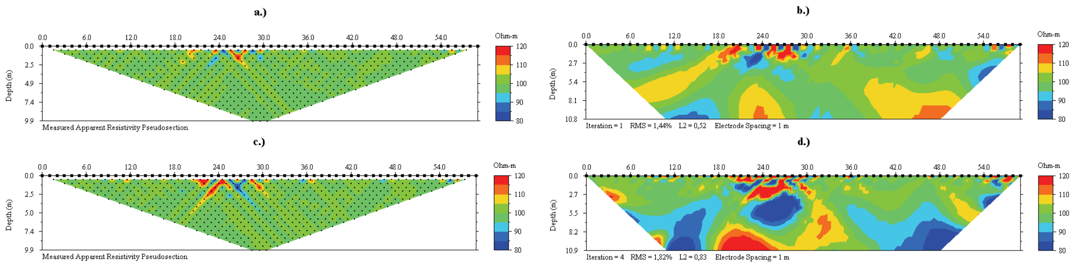

Figure 2: *Apparent resistivity profiles (a and c) and inverted pseudosections (b and d) for the Wenner-α and Wenner-β arrays, taking into account the actual positions of the electrodes along the measuring line P4.*

In case of more significant surface rockiness the false anomalies may become much higher. We carried out several experiments with significant surface rockiness along line P4 and P3. In the first experiment we tried to put the electrodes as close to their ideal position as possible. In spite of this effort, the positional inaccuracies in both x and y directions in case of 9 electrodes among the 60 ones) proved to be higher than 10 cm (10 p.c., assuming an electrode distance of 1 m).

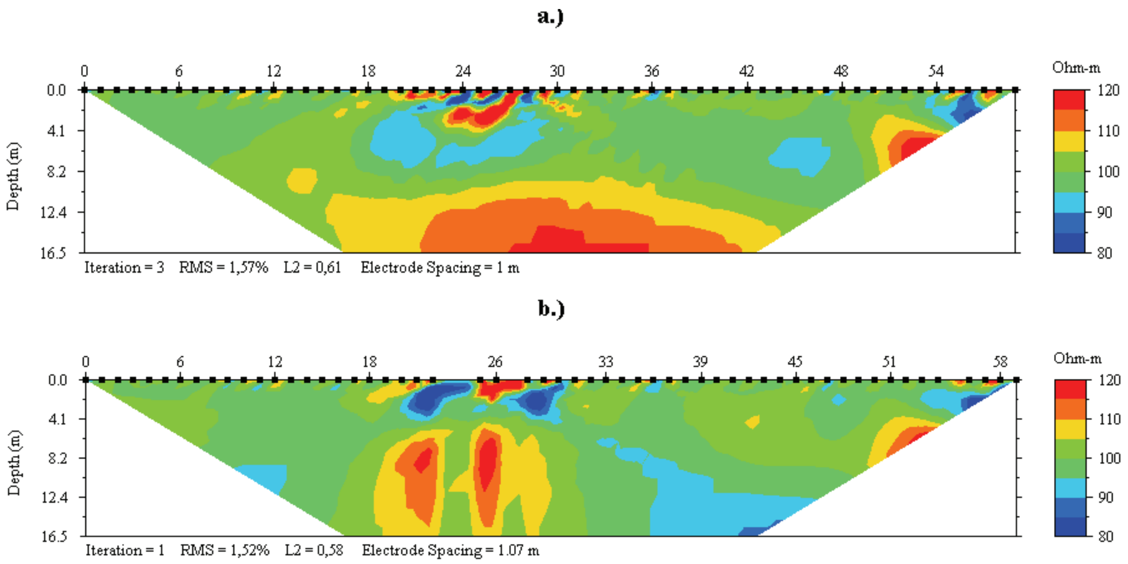

Figure 3: *Inverted resistivity pseudosection for the pole-dipole array along line 4, where the positioning inaccuracies were significant both in x and y directions. a) considering all electrodes; b) ignoring four electrodes (23, 24, 27 and 55), where the positioning error in x-direction was larger than 15 cm.*

The inverted resistivity pseudosection (Figure 3a) for the pole-dipole arrays indicates very false anomalies. One of them is seen with a centre at 30 m at a depth of about 10 m. This false anomaly could not be removed neither by ignoring even all those (four) electrodes where the positioning error $|x_{ideal}-x_{real}|$ was larger than 15 cm (Figure 3b), nor by ignoring the four electrodes where $|y_{ideal}-y_{real}|$ > 30 cm (not shown). It should be remarked that ignoring electrodes could be in theory a way to reduce such false anomalies, but ignoring so many (4 or 4+4) electrodes may already endanger the correct interpretation.

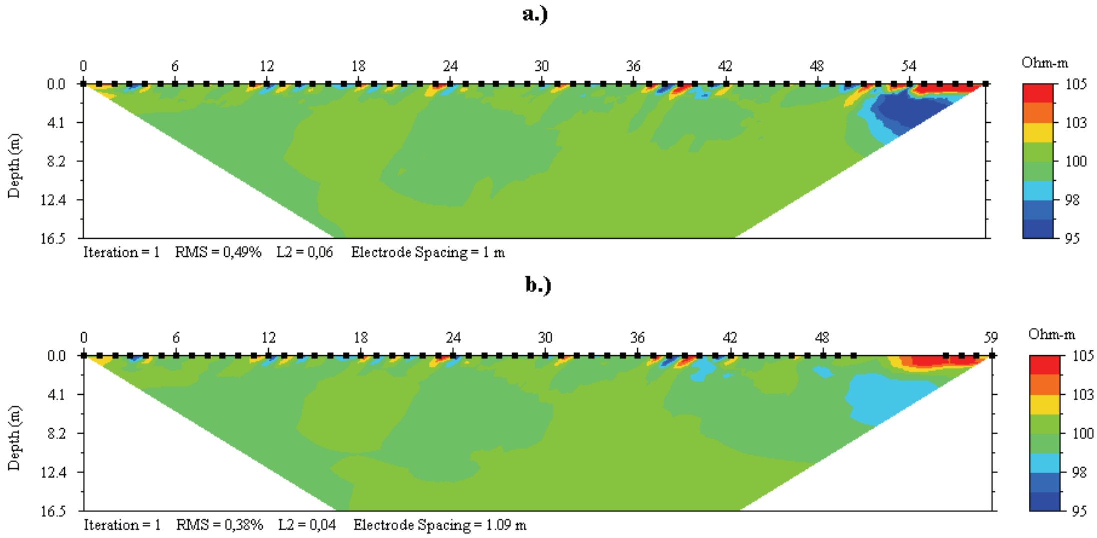

Figure 4: *Inverted resistivity pseudosection for the pole-dipole array, along line P3 (where the surface rockiness was high, but the positioning errors occured mainly in y direction. a) considering all electrodes, b) removing four electrodes (51-55, ez 5 elektróda), where* $|x_{ideal}-x_{real}|$ > *6 cm*

Besides ignoring the electrodes there is an alternative way to reduce the noise effect. When it is not possible to put the electrodes in their theoretical position, we recommend to commit the positioning error in rather in direction y (at right angles to the measuring line) than in direction x. In this case the false anomalies become less significant (both in their magnitude and extent), and remain important only in the near-surface region (except when the deviation is extremely big). This result was obtained along profile P3 (Figure 4a), which is similar to P4.

When deviations are caused by only 1-2 electrodes, they can be easily ignored in the inversion procedure, without endangering the correct interpretation.

In Figure 4 $|y_{ideal}-y_{real}|$ was higher than 20 cm for five electrodes (electrodes 40-44). Nevertheless a significant false anomaly appeared only at the end of the measuring line (electrodes 51-55), where the positioning errors arose in x direction! Ignoring all those electrodes, where $|x_{ideal}-x_{real}|$ > 7 cm, the inverted pseudosection become less distorted (Figure 4b).

In Figure 5 the histogram of x- and y-directed positioning errors are shown. In line P4, where we tried to keep $|\mathbf{r}_{ideal}-\mathbf{r}_{real}|$ on a minimum level, similar histograms were obtained for x- and y-directed errors. At the same time, where we tried to keep a minimum $|x_{ideal}-x_{real}|$, the x-directed positioning errors are much less, while the y-directed ones remain significant over a wide range.

CONCLUSIONS

In this study we investigated the consequences of positioning errors on the interpreted results, among real field conditions, where the coordinates of the electrodes differ from their theoretical ones. The actual positioning errors were determined by means of a laser distance meter, then the effects of positioning errors on the apperent resistivity- and inverted resitivity pseudosections were computed, assuming a homogeneous and isotropic half-space. Such computations were carried out for Wenner-α and -β, pole-dipole and pole-pole geoelectric arrays.

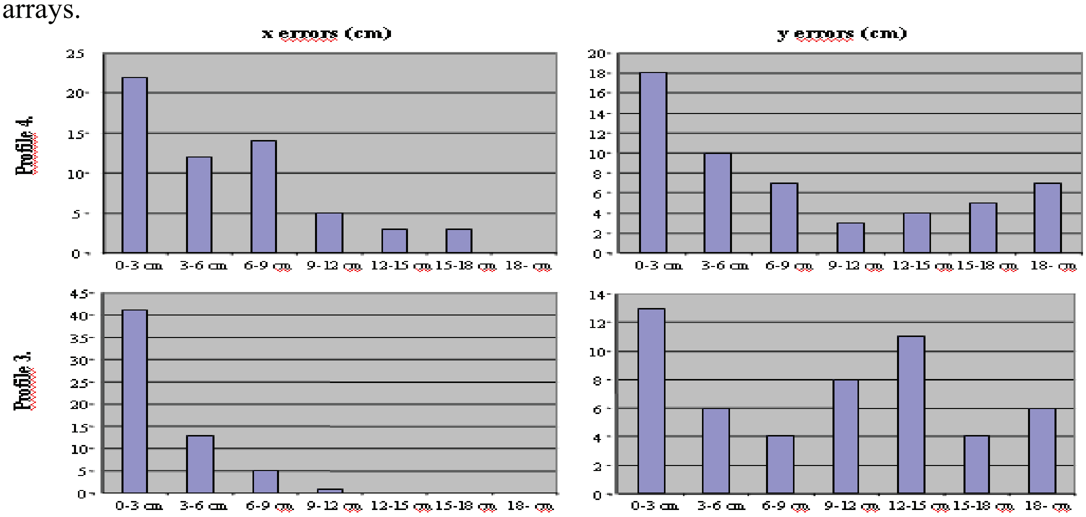

Figure 5: *Distribution of x- and y-directed positioning errors (x-directed errors: left, y-directed errors: right) along lines P3 (bottom) and P4 (top)*

The noise of positioning origin proved to be relatively low among even very unconvinient field conditions, and they have influence first of all only to the near-surface data, which are not so important for the interpretation.

Nevertheless, in case of high surface rockiness, where the rocks do not make possible an exact positioning of the electrodes, the consequences may be more significant. The risk is even higher in case of small electrode distances, due to the relatively higher percentage of the positioning error.

In order to be able to eliminate these problems, it is advisable 1) avoid areas where the surface rockiness is important (if it is possible at all), 2) try to keep $|x_{ideal}-x_{real}|$ on minimum, even on the price of higher $|y_{ideal}-y_{real}|$ values, 3) if we have only a few electrodes with wrong position, it is possible to ignore them, and to carry out the inversion without these data, 4) it would be useful to eliminate this effect, taking into account the real position of the electrodes. Keeping all these things in mind, the reliability of the data will improve, even in case of high surface rockiness.

At the same time, as for the consequences on numerical modelling one should know the followings. 1) The consequences of the positioning errors on the pseudosection of apparent- and inverted resistivities depend very much on the array geometry (the increasing order of these effects is: PP, Wa, PDP, Wb) 2) the error propagates systematically and not randomly. Consequently in the inverted resitivity images the size of the false anomalies can be large.

It is worth confronting our conclusions and the numerical practice, since in the numerical modelling practice 1) the random error is assumed be the same, indifferently on the array, 2) to the forward-modeled data always a random error is added.

In the light of our conclusions it would be especially important to investigate in details, if the assumption of numerical modelling about a random error is at all realistic.

ACKNOWLEDGMENTS

Hungarian National Scientific Research Fund (projects K049604 and NI61013).