MADRID 2015
1-4 June 2015 | IFEMA Madrid

Tu P5 14

The First Inversion Results with the g11n Configuration

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SUMMARY

Geoelectrical null and quasi arrays have been studied since very long time, but they have not been introduced in the practice. Its reason is that their application was rather difficult and that the inversion of the data of the arrays whose application is simpler has not been solved. We studied the theory of these arrays and developed a code to invert their data. In the presentation a short introduction will be given in their theory and the very first field experiments will be shown.

Introduction

There are a number of geolectric null (and quasi null) arrays (Fig. 1) which have been studied for a long time, but they have not been introduced into the practice. In the beginning the main reason was their difficult applicability. Szalai *et al.* (2002) applied geometrical null arrays whose application was not as difficult. Although they proved to be very useful in the test measurements they could not been involved in 2D research. Therefore the MAN array and the γ quasi null arrays (Fig. 2) were introduced by Szalai *et al.* (2004). They have shown that the MAN array may produce higher anomalies than the traditional geoelectric arrays especially when the inhomogeneity is in large depth. The applicability of these arrays, too, has been verified in field by Szalai *et al.* (2004) in spite of the significant fear of the effect of the noises. In the last years several numerical and field studies have been carried out by the MAN array and its quasi null array versions the so-called γ quasi null arrays, which are between the null and traditional arrays according to their theory. The first inversions have been made by the EarthImager, but it was only able to invert data obtained over small-effect inhomogeneities. For such anomalies the results were remarkable (Fig. 3). These arrays may however produce data with negative signs and due to their very/extremely large geometrical factor the resistance values have to be obtained and inverted. Using an own-developed code (Prácser, 2007) we could invert such data. In the presentation the very first results are shown.

Theory

From the about 100 geoelectric arrays which have ever been used almost the one forth, 25 are null arrays that is arrays which give zero value over a homogeneous half-space (Fig. 1). Most of them however belong to groups III-VII (Fig. 1) following the classification of the arrays by Szalai *et al.* (2008) that is they are the superposed or focussed arrays whose field application is rather difficult. Szalai *et al.* (2002) introduced therefore geometrical null arrays where the appropriate positioning of the electrodes results in null array situation. The Schlumberger null- (Nr 23. in Fig. 1), the three-electrode null- (Nr 24. in Fig. 1), and the dipole axial null (Nr 30. in Fig. 1) arrays were tested on a parallel profile to a quarry wall to detect fractures in limestone (Szalai *et al.*, 2002). Although the test was successful we decided to study null arrays which are linear and applicable also in 2D situations.

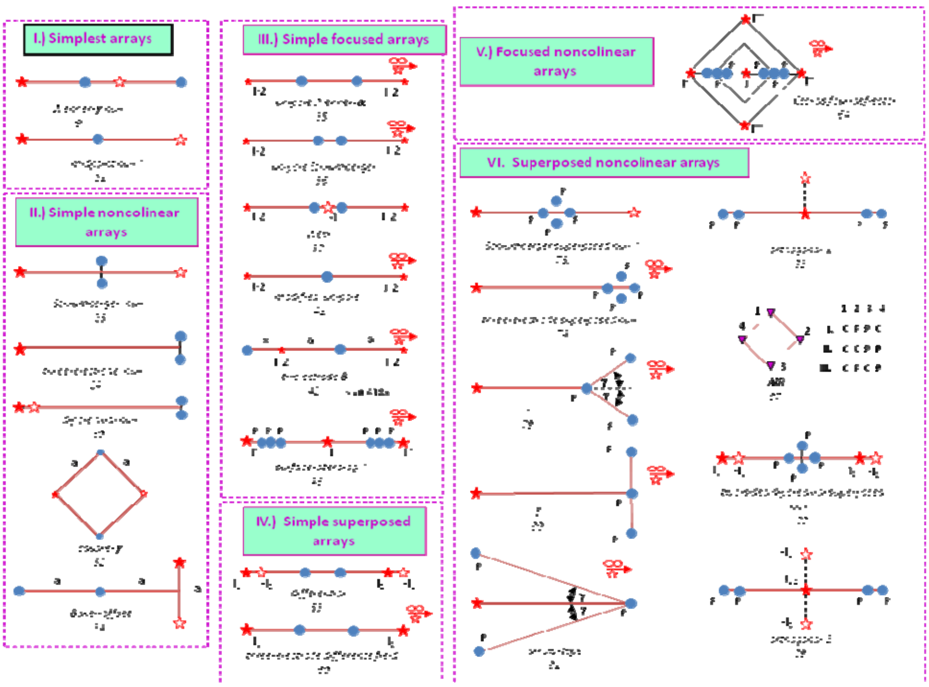

Figure 1 *The ever used geoelectric null arrays (from Szalai and Szarka, 2011). Source/sink electrodes are full/empty stars. P: potential electrode (full circles). The lower-case letters such as e, p, c indicate electrodes at infinity.*

It can easily be shown that there are only two linear null arrays which have symmetry features: the MAN, or midpoint null-, or γ_{11n} array (Nr 21. in Fig. 1 and the last array in Fig. 2c if n=*inf*, Tarkhov, 1957) and the γ quasi null array (Fig. 2b). It was shown by Szalai *et al.* (2004) that the MAN array presents larger anomalies than the Wenner array if the inhomogeneity is in large depth. They have also shown that null arrays produce well detectable anomalies also in the field even without taking any special attention to the precise positioning of the electrodes.

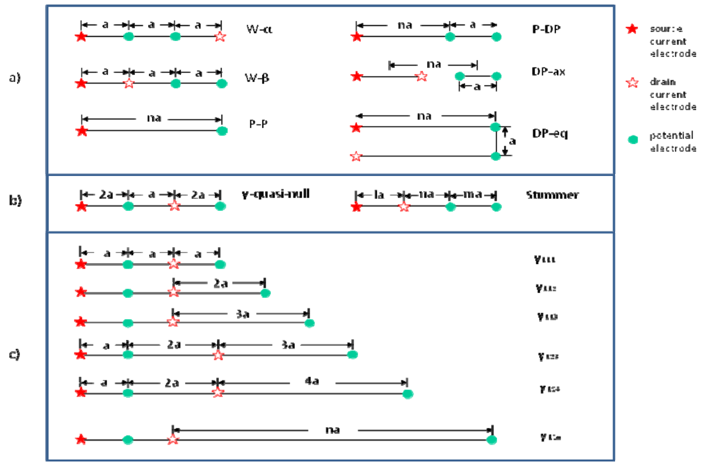

Figure 2 *a) Traditional arrays b) γ quasi null and Stummer arrays. c) γ11n arrays. If n=inf. the γ11n array turns into the MAN array. Stars denote current electrodes, circles denote potential electrodes.*

It seemed to be therefore worthwhile to study the possibility of building in such arrays in multielectrode systems. Unfortunately for this aim only the MAN array can be used because of the demand of the equidistance of the electrodes. Studies of this array motivated us however to investigate rather arrays which are similar to the MAN array but neither of their electrodes is in the infinity. The infinite electrode lead namely to serious problems both in the practice and in the numerical modelling. In the present stage of the research we study therefore the so-called γ_{11n} arrays (Fig. 2c) which are between a traditional array, the γ_{111} one (the well-known Wenner-γ array) and the MAN array. These arrays represent therefore a transition from a conventional array to a null array. Beside of the theoretical interest of this transition it results in different images supposed to have different drawbacks but also advantages (see e.g. Fig. 3).

Because these arrays may have negative signals and because there may have infinitely large apparent resistivity values acquisition of resistance data is required. The EarthImager software proved to be appropriate to handle such data if they were generated by the program itself and if the effect of the inhomogeneity was not large. Figure 3 presents images which has been created by these arrays and by the Wenner-α and the optimised traditional array, the Stummer array (from Szalai *et al*. 2015). In many examples – like also in the here presented one - the γ arrays, or many of them produced better results than even the optimised traditional array. Unfortunately not even this software could handle our field data therefore the ERT2DInv code was developed (Prácser, 2007). It uses FEM method and linearized smoothed inversion algorithm.

In the first step we carried out field measurements over a tube close to the surface (Fig. 4). It was supposed that it can be well seen by all configurations and that the traditional configurations will produce better results for these parameters. Our expectations have been fulfilled. (For the configuration of the traditional arrays see Fig. 2a) We studied also the γ-quasi null array (Fig. 2b) which is the modified version of the Wenner γ-null array. With a small modification of the interelectrode distances we got an array close to the null array but it can be build in ERT systems. In its image the corners of the section are strongly distorted. The anomalies of the traditional arrays are remarkable as it was expected. We think however that if such a body would be in larger deepth the γ arrays would be more useful. To verify this statement however one should find appropriate test site.

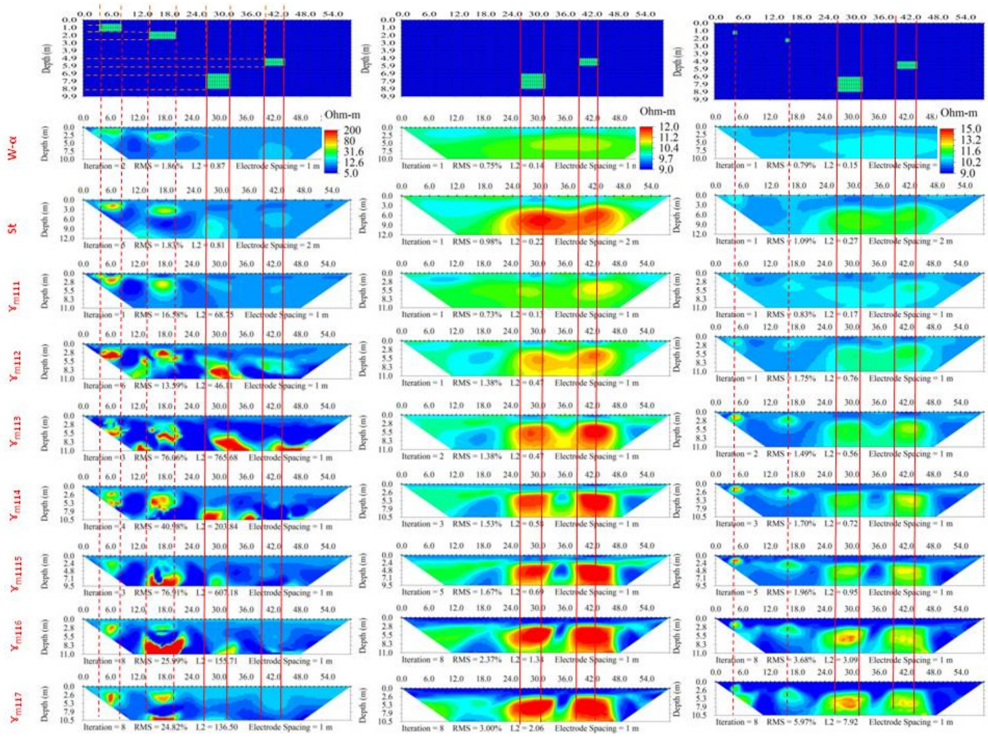

Figure 3 *Left column: Inversion results from the Wenner-α, Stummer and γm11n (n=1-7) configurations for the model similar to that in Wilkinson et al. (2006). Middle column: results for the same model without the near-surface anomalous bodies. Right column: the first model with smaller near-surface inhomogeneities. The models are given in the first row.*

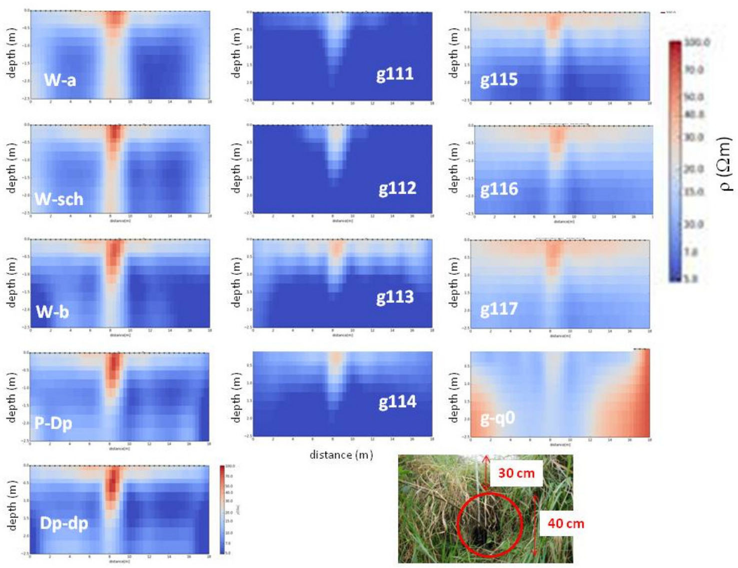

Figure 4 *The first inverted γ_{11n} array field data over a tube. The profile was perpendicular to it. Below the image of the tube with its parameters.*

What now we can see is that if the measuring profile is not perpendicular to the tube (Fig. 5) only the γ arrays seem to present the effect of the parts of the tube which is not directly below the profile. These arrays seem therefore to be more sensible to the parts of the inhomogeneity which are further away from the profile. Because the current is supposed to flow in about a half cylinder it has to mean that they are also more sensible to inhomogeneities which are deeper as it has already been supposed on the basis of the theoretical and numerical investigations. To verify this statement inhomogeneities in different depths would be necessary. It is expected that there is a depth range where the traditional arrays are not anymore able to detect the inhomogeneity while the γ arrays are still able to do it. Such test sites are still looked for.

Conclusions

Geoelectrical null-, and quasi arrays have been studied since very long time, but they have not been introduced in the practice. We give a short introduction into the theory of the γ arrays and show the very first inverted field data results. These results are promising. Now appropriate test sites are looked for.

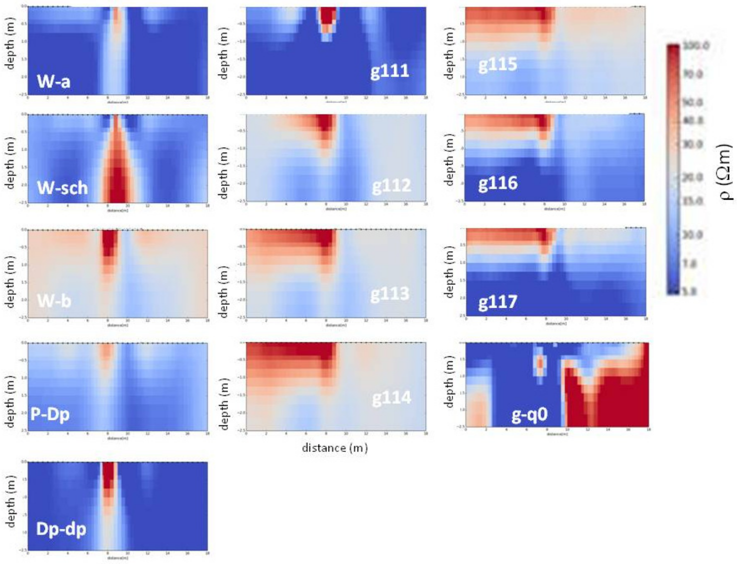

***Figure 5** The first inverted field data over a tube. The angle between the tube and the profile is 50°.*

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