THE STUDIED NULL-ARRAYS

The term “geoelectric null-array” is introduced for those D.C. electrode configurations, where the measured or the interpreted potential difference is zero above a homogeneous half space. A classification of all known null-arrays is shown in Figure 1. While the arrays belonging to the second column (where not the measured, rather the derived quantities are zero) and to the third one (that is the focussed arrays) have already been used earlier, the arrays in the first column (where directly the measured value is zero) – in spite of their simplicity – were used at first by the authors. These latter arrays represent current fields at various typical distances from the current electrodes, and at the same time, they can be easily constructed from traditional arrays (Szalai et al., 2002). The pairs of traditional and non-traditional arrays, presented in Figure 2, are as follows.

I) MN (M₀N₀) is close to one of the current electrodes. In this case the current lines are nearly radial around the current electrode. According to the analogy of the classical three-electrode configuration AMN, the AM₀N₀ configuration is called as the three-electrode null-array;

II) MN (M₀N₀) is between the two current electrodes. Here the current lines are nearly parallel. A special situation in this group is the Schlumberger (or AM₀N₀B) null-array, when the center of M₀N₀ is in the connecting line between A and B, at an equal distance from both current electrodes;

III) MN (M₀N₀) is far from the current electrodes. In this case the current source may be considered as a dipole. Two null-arrays can be easily constructed from well-known traditional configurations:

IIIA) the dipole axial null-array; IIIB) the dipole equatorial null-array.

Fig. 1. Classification of D.C. null-arrays.

The measured or derived quantitives are zero over a homogeneous halfspace.
NULL-ARRAYS ON BASIS OF THEIR PARAMETER-SENSITIVITY MAPS

To understand the mechanism of geoelectric null-arrays their parameter-sensitivity maps were calculated (for general definition see e.g. Barker, 1979; for parameter-sensitivity maps of dipole-dipole arrays see Szalai and Szarka, 2000). Figure 3 presents a parameter-sensitivity map for the dipole axial null-array. The values of isolines show the percentage of effect due to a small cube in a given place (at a depth of one tenth part of the dipole-dipole distance) obtained by this null-array with respect to the homogeneous half space value in the field of the corresponding traditional array.

The antisymmetry about the y/R=0 axis in Figure 3 indicates that any anomalous body, which is symmetrical about this axis has zero contribution to the resulting field. Due to this symmetry, the effects of pairs of related small portions of a long body (those at distances +y/R and −y/R in the rectangular body, shown in Figure 3) are mutually cancelled out. E.g. all one-dimensional cases, the two-dimensional bodies, whose dip directions coincide with the y/R=0 axis and the three-dimensional bodies having their symmetry axes coincident with the y/R=0 axis, all of them have zero response.

The most important features of the null-arrays can be directly derived from their parameter-sensitivity maps.

The null-arrays
(1) have zero signal above homogeneous half space, 1D, 2D, and even above 3D structures which are symmetrical to the characteristic line (axis) of null-arrays. Consequently the null-arrays are very sensitive to the asymmetry of inhomogenities;

(2) are able to detect anomalous bodies in offset position;

Fig. 2. Three characteristic traditional arrays and their corresponding null arrays (Szalai et al., 2002)

Fig. 3. Parameter sensitivity map for dipole axial null-array (Szalai et al., 2002). Effect of symmetrical anomalous bodies (that is the rectangular body shown in the figure) is zero.
(3) measure 3D anomalies with intensities that are about one tenth of anomalies measured by traditional arrays. Nevertheless, this signal is still measurable and it is not mixed with the signal merely due to the homogeneous half space.

From (1) it follows that a fissure is either parallel with or perpendicular to the array axis, produces a zero measured value (see Figure 4). At any other angle the signal is different from zero, so the measured diagram has a shape shown in Figure 6.

FIELD MEASUREMENTS
In this summary field measurements, demonstrating the effectivity of null-arrays in localisation of fissures and in determination of fissure directions are presented. Results for traditional and null-arrays along a profile, running parallel to the quarry wall (8 m from it) are seen in Figure 5. According to the parameter sensitivity maps (confirmed by 3D numerical modelling studies) the fissures are indicated by local minimas. The null-array anomalies are more characteristic, and as it was confirmed, they give information about fissures at greater depths than the traditional arrays. (See the second part of the profile, where the sediment is thicker.)
The strike direction of these fissures – based on Figure 4 – is given by sharper and narrower minimum zones using the null-arrays than using the traditional ones (see Figure 7). There was found a very good correlation between the reality and the measured direction values by using the Schlumberger null-array (Szalai et al., 2002), electrode- and the Schlumberger array pairs (Szalai et al., 2002).

Fig. 4. Interpretation of azimuthal diagram obtained by using Schlumberger null-array

Fig. 5. Field responses obtained by the three-electrode- and the Schlumberger array pairs (Szalai et al., 2002)
Such a direction determination is possible even in case of multiple field directions (Szalai et al. 2001). In the azimuthal diagram in Figure 7, the possible strike directions manifest themselves by close-to-zero values: by six possible direction intervals with the null-array (all of them are sharp), and three directions with the traditional array (they are not well defined). In order to select the three true directions from the six possible ones, and in order to give precise direction information, one should use both diagrams simultaneously.

Fig. 6. Azimuthal diagrams for determination of fissure strike direction as measured in the field by using corresponding traditional and null-arrays. The null-array gives sharper, but two possible direction intervals. The ambiguity is resolved by means of the traditional array results.

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Fig. 7. Azimuthal diagrams by using traditional array and its corresponding null-array. The field study was made in an area with multiple fissure directions.

CONCLUSIONS

In this paper some theoretical aspects and of a new type of D.C. null-arrays have been summarised (based on their parameter sensitivity maps), and then theoretical results have been illustrated by field case studies. These null-arrays can be constructed very simply from their traditional pairs, and a joint use of traditional and null-arrays give important complementary information, e.g. in localisation of fissures and in determination of their direction.

REFERENCES


