

Resistivity Vertical Filtering for Horizontal Prospecting Physical Basis and Archaeological Case Histories

An important question in archaeological geophysical prospecting is the separation between anthropic and natural geological features. Generally the archaeological features are near the surface so that it is possible to distinguish them from the natural ones through suited investigation depths.

It is well known that electrical resistivity prospecting is a good method for the adjustment of the investigation depth owing to the electrode spacing. But the investigation depth and the electrical image are strongly dependent on the electrodes arrangements. The "archaeological" arrays are the twin electrode, the pole-pole, the square and the Wenner. In this paper it is shown that the pole-pole yields a very good discrimination between shallow and deep buried features. The pole-pole array is an improvement of the twin electrode (1) in the sense that remote electrodes are far from each other so that the readings provide the true apparent resistivities without any problem of continuity between adjacent grids.

The physical basis of the behaviour of the pole-pole array can be deduced from synthetic results about the anomaly created by a small body on a pseudo-section. Indeed, when comparing the anomalies of a small body imbedded in homogeneous ground obtained with several archaeological arrays, one sees that the pole-pole anomaly has a better resolution in the horizontal direction and also in pseudo-depth (2). This advantage of the pole-pole over the other arrays for depth discrimination is reinforced

by two other properties: its technical simplicity (only two mobile probes) and its largest investigation depth (3). Thus, for a given investigation depth, the pole-pole array has the smallest dimensions of all arrays.

We show that multi-spacing pole-pole maps allow an efficient vertical filtering of anomalies in cases which would be otherwise hard geophysical problems. Case histories are the search for ditches in karstic geology, the detection of stony burial structures on very shallow resistive substratum, the separation of superimposed structures in a Roman town (4) or, on the country, the proof of the absence of any buried anthropic structures.

References

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Reconstructing the 3-D Distribution of the Magnetic Field Data and its Application

In geomagnetic survey, we usually measure the magnetic field only on one 2-D plane. In this study, the authors will propose the method of reconstructing the 3-D distribution of the magnetic field data from the 2-D magnetic field data and its application to estimate of the shape and the depth of the magnetic bodies. For example, in the case that two magnetic bodies are buried and one magnetic body is just above another one, only one magnetic anomaly is observed on a horizontal plane over these bodies. However, if we could assume a vertical observation plane in the ground and obtain the magnetic field data on the plane, we would find two magnetic anomalies on this virtual plane.

The magnetic field distribution on $z = z_1$ plane can be calculated from the magnetic field on $z = z_0$ plane using 2-D Fourier transform as

$$F[\mathbf{B}_{z_1}] = F[\mathbf{B}_{z_0}] \exp(-|\mathbf{k}|(z_0 - z_1)),$$

where \mathbf{B}_{z_0} and \mathbf{B}_{z_1} are magnetic field on $z = z_0$ and $z = z_1$ plane, $F[\cdot]$ is the 2-D Fourier transform, $\mathbf{k} = (k_x, k_y)$ is the 2-D wave-number vector and $z_0 > z_1$. Applying this equation repeatedly to the 2-D magnetic field data on 2-D planes with various inclinations, the 3-D distribution of the magnetic field data in regular region can be reconstructed.

Assuming an appropriate plane in the 3-D space and applying the reduction to the pole technique to the reconstructed magnetic field data on the plane, we can estimate more accurately the shape of the magnetic bodies.

The Fourier spectrum of the magnetic field data produced by one magnetic body in logarithmic scale is presented as

$$\log |F[\mathbf{B}_{z_0}]| = -|\mathbf{k}|(z' - z_0) + \text{Constant},$$

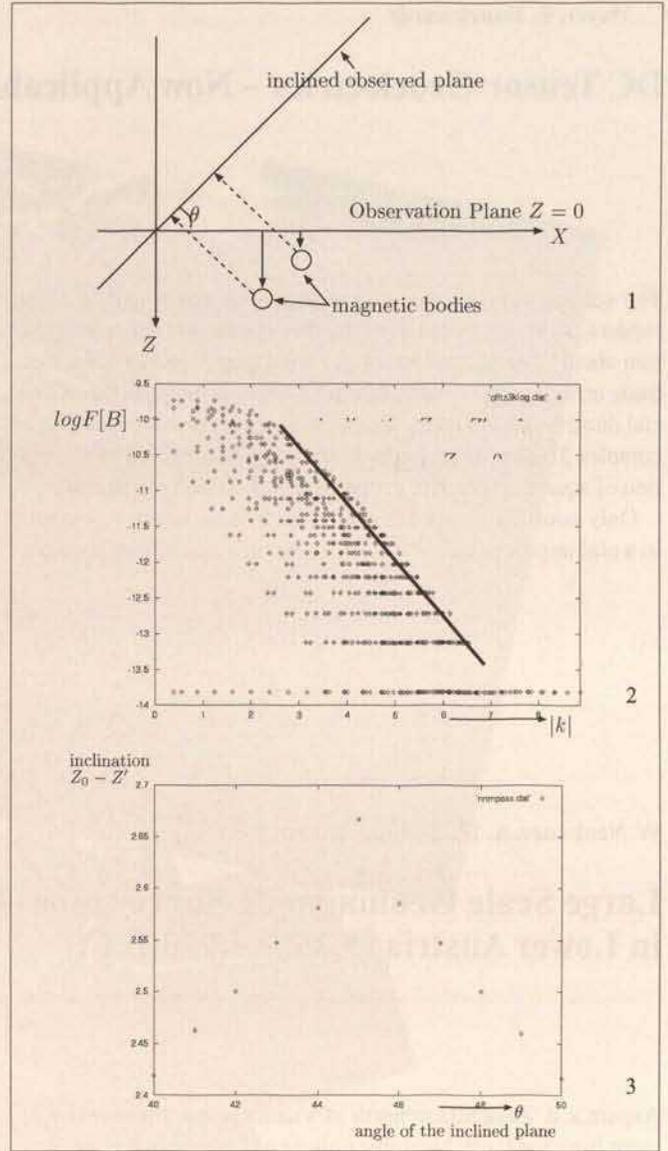
where z' is a depth of the magnetic body, z_0 is a vertical coordinate of the observation plane. Thus, we can estimate the depth of the magnetic body from the inclination of the logarithmic spectrum of the magnetic field data. However, if there are many magnetic bodies, it indicates only the depth of the shallowest body. In this study, the authors will propose the method to determine the depth of these magnetic bodies even if more than one magnetic bodies are buried in different depth. In a simple case that two magnetic bodies are buried in different depth, as the observation plane is inclined with angle θ , each distance between the observation plane and the magnetic bodies changes. At a particular angle θ' , these distances are equal to each other. So, the depth of both magnetic bodies can easily calculate from the angle θ' geometrically.

For example, two magnetic dipoles are buried shown in Figure 1. The Fourier spectrum of the magnetic field data on $z = 0$ plane is shown in Figure 2. Figure 3 shows that the inclination of the logarithmic spectrum of the magnetic field data on the virtual observation plane varies as the inclination angle of the plane is changed every 1° between 40° and 50° . We can easily find a bending point at $\theta' = 45^\circ$ in figure 3; then, we can estimate the depth of each body.

Fig. 1. Simulated model for buried magnetic bodies

Fig. 2. Fourier spectrum of magnetic field data observed on $z = 0$ plane.

Fig. 3. Inclination of logarithmic Fourier spectrum of magnetic field data vs. angle θ of the observation plane



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Development of a System of Geoelectrical Data Acquisition and Elaboration

The aim of the paper is to illustrate a system of acquisition, elaboration and interpretation of data obtained by geoelectrical prospecting in the upper level of the ground for archaeological research. The energising equipment furnishes an A.C. sinusoidal current with frequencies between 40–380 Hz. The generator has been set with two tension outputs to utilise two different energising dipoles during the survey. In this way it is possible to elaborate data in a tensorial form to obtain apparent resistivity maps in conformity with the actual anomalies distributions. Measurements are taken over rectangular areas using two dipoles of different sizes which are fixed perpendicularly on a mobile frame. In this way, for each measurement point, it is possible to evalu-

ate two different components of the induced field. (The current probes are kept in the same place while all the voltage measurements are taken in the chosen area). The method proposed allows the measurement to be taken quickly. No induction effects are shown in the cables at the above mentioned frequencies interval. The acquisition system is based on a PC with a 16 bits card, a filter-amplifier provides elimination of natural and artificial disturbances. Without filtering it is possible to acquire four temporal series obtaining SP and geoelectrical measurements. For each measured area a software was developed under the PC environment to perform the invariants map of the apparent resistivity tensor, directly in the field.