P132 TOMOGRAPHIC INVERSION OF THE ELECTROMAGNETIC DATA — INDUCTION LOGGING, TEM-TDEM

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SUMMARY. A fast imaging technique is developed to deduce the spatial conductivity distribution in the earth from low-frequency (< 1 MHz) electromagnetic measurements. A vertically orientated magnetic dipole is the source of the EM field. It is assumed that the scattering bodies are azimuthally symmetric about the dipole axis. The use of this model geometry reduces the 3D vector problem to a more manageable 2D scalar form. Additional efficiency is obtained by the linear approximation for the magnetic fields generated by inhomogeneities embedded in a layered earth. The inversion problem is accomplished by the inversion of the linear system.

LINEARIZATION OF THE FORWARD PROBLEM. We assume that

$$\sigma = \sigma_0 + \Delta\sigma \quad \text{and} \quad \vec{H} = \vec{H}^0 + \vec{h}, \quad \vec{E} = \vec{E}^0 + \vec{e}, \tag{1}$$

where σ_0 is the conductivity of the reference "normal" medium and $\vec{E}^0, \vec{H}^0$ are the "normal" field, σ_0 is a conductivity of the 1D medium. So, for the anomalous field we get the following first Maxwell's equation:

$$\text{rot}\,\vec{h} = \sigma_0\vec{e} + \Delta\sigma \cdot \vec{E}^0 + \Delta\sigma \cdot \vec{e}. \tag{2}$$

Now we neglect by $\Delta\sigma \cdot \vec{e}$ and we consider $\Delta\sigma \cdot \vec{E}^0$ as a known current. In this case ($E^0_\varphi = I \cdot \mathcal{E}(r, z, r_0, z_0)$) we obtain the linear dependency between the electromagnetic measurements and the distribution of the additional conductivity:

$$E_\varphi(r, z, r_0, z_0) = I_0\mathcal{E}(r, z, r_0, z_0) + I_0 \sum_{j=1}^{K} \Delta\sigma_j \cdot G_j(r, z, r_0, z_0), \tag{3}$$

where

$$G_j(r, z, r_0, z_0) = \int_{r_{1j}}^{r_{2j}} \int_{z_{1j}}^{z_{2j}} \mathcal{E}(\bar{r}, \bar{z}, r_0, z_0)\mathcal{E}(r, z, \bar{r}, \bar{z})\, d\bar{r}\, d\bar{z}. \tag{4}$$

INVERSION. Estimation of the anomalous conductivity is accomplished by the solution of linear system (3). We get solution by the singular values decomposition and least squares inversion.

EXAMPLES. Figure 1 shows the results of the 2D tomographic inversion of the synthetic induction log data. The array include 10 receiver coils and use 6 frequencies. 9 locations of the array are applied. So, 540 linear equation are used for the evaluation of the resistivity in 32 regions. Figure 2 shows the 1D tomographic inversion of the synthetic TEM data. The array is the coaxial loops located on the Earth's surface.

In both cases the reference medium is the homogeneous half-space. The time of the inversion less than 1sec, if the finished factors G_j are used.

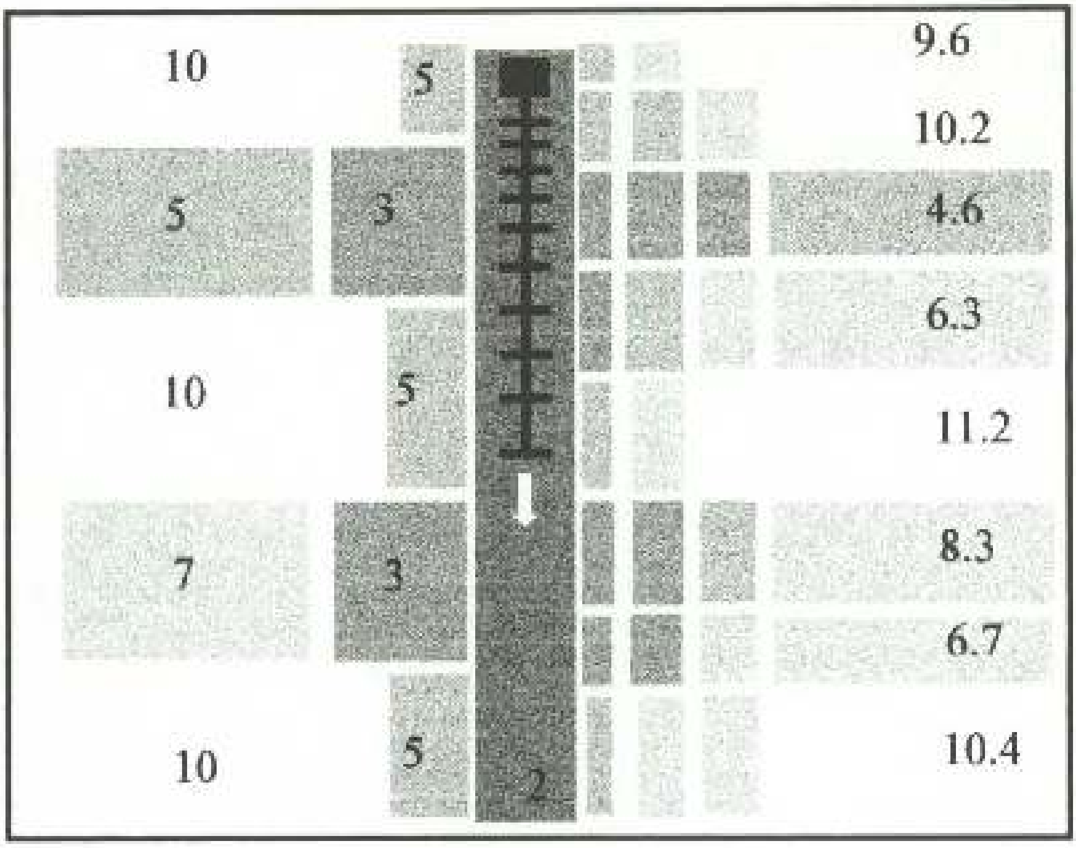

Fig. 1. Induction logging. Model (left) and image (right).

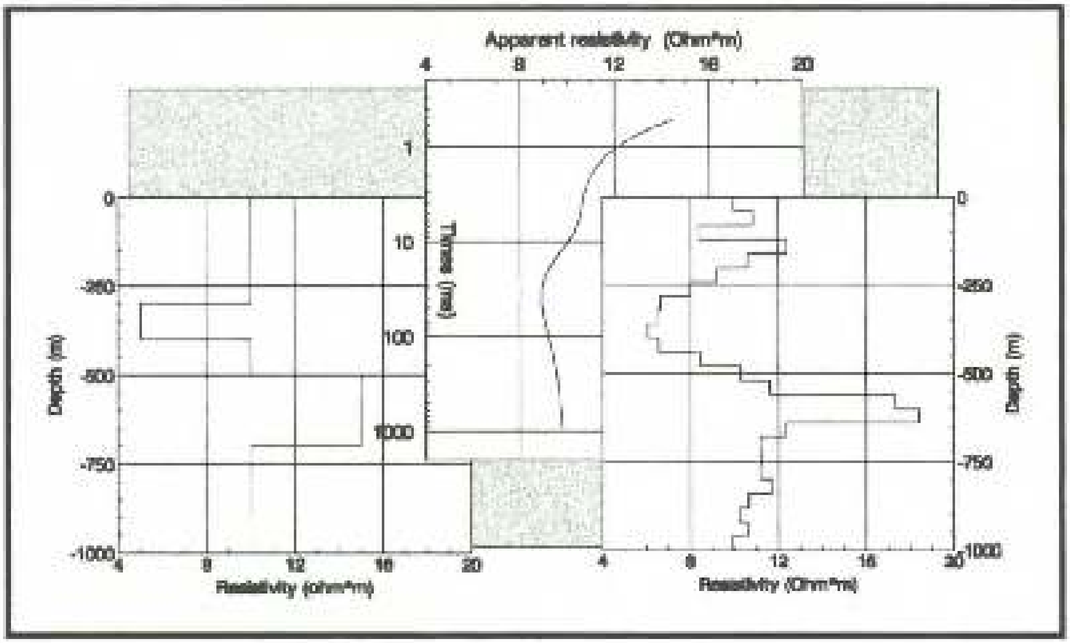

Fig. 2. 1D tomographic inversion of the TEM data. Model and image.