ILLUSTRATION OF SOME 3-D MAGNETOTELLURIC PARAMETERS
ON A FESTIVE OCCASION

LÁSZLÓ SZARKA

In this paper a special illustration of 3-D magnetotelluric interpretation parameters, including the rotational invariants of the impedance tensor is given. Celebrating his 70th birthday, magnetotelluric responses of high conductivity thin-sheet models, forming the letters of the name of ERNŐ TAKÁCS have been computed in both principal directions, using the so-called "deep thin-sheet code" by Taritas (1989). Resistivity- and \( R_{\text{ab},\text{cd}} \)-maps and also rotational invariant maps are produced. Some basic phenomena, like current-cannelsing, charge-accumulation at current inflow- and outflow sites and also the geometry-sensitivity of some rotational invariants over such very special models are shown on this festive occasion.

László Szarka
DSc (earth sciences)
head of the Geophysical Department
Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences,
H-9400 Sopron, Castzsiu u. 6-8. (H-9401 Sopron, PO Box 5)
INTRODUCTION

In the seventies, when the author was a student of Prof. Ernő Takács, the 2-D forward modelling was a hot problem. Although nowadays a number of 3-D forward and inverse problems have already been numerically solved, the number of unsolved questions is higher than it was 20 years ago.

In 3-D magnetotellurics the impedance tensor cannot be simplified with rotation. It has four complex elements in the general case, and there is in practice a very large number of different possible interpretation parameters. A general opinion seems to be articulated that 3-D anomalies can be plotted in "too many" ways. There is a tendency to find the most appropriate ones. In a recent paper (Szarka and Menvielle, 1997), some systematically selected rotational invariants of the magnetotelluric impedance tensor have been proposed to use as 3-D imaging parameters.

On this festive occasion the author presents an unusual illustration of several different 3-D interpretation parameters over specially selected 3-D thin-sheet models.

MODEL PARAMETERS

The theory, the description of computer codes, the basic model parameters are described in details in our earlier papers (Tarits, 1989, Szarka, Menvielle et al., 1994a, 1994b, 1994c, Szarka, 1994). The plan-views of thin-sheet high-conductivity plates (having a frame size of 4km x 4km, a thickness of 100m, a resistivity of 1Ωm and a depth of 2km) form different letters and numbers as T, A, K, Ā, C, S, E, R, N, Ō, 7 and 0. In all models, the host resistivity in the upper 4km is 500Ωm, and for the bottom resistivity 5000Ωm was selected. The magnetotelluric responses for a measuring area of 20km x 20km were determined at a period of T=100s. Two basic directions (N-S and E-W) were computed and all magnetotelluric parameters in other directions were determined by simple rotation formulas. Responses of different models were computed independently from each other. The twelve independent anomaly maps are connected in order to be able to read the coherent text as follows: "TAKÁCS ERNŐ 70".

RESULTS

In the first four figures results in the two basic directions: resistivity- and Hx|zax|Hx|zax| maps are shown. Figure 5 and 6 illustrate the situation, where the inducing electric field has a direction of 45
Figure 1: $p_{12}$ apparent resistivity maps, when the inducing electric field has N-S direction (All maps are products of the SURFER program package, using default parameters.)
Figure 2: Numerical maps (real parts) when the inducing electric field has N-S direction.
Figure 3: An apparent resistivity map, when the inducing electric field has E-W direction.
Figure 5: $\rho_{13}$ apparent resistivity maps, when the inducing electric field has NE-SW direction
Figure 6: \( N_{\text{real}} \) maps (real parts), when the inducing electric field has NE-SW direction.
Figure 7: An example illustrating the unfavorable characteristics of the SKEW (the real part of the complex skew is shown).
Figure 8: An example, illustrating the favourable characteristics of a carefully selected rotational invariant: the real part of the determinant of the impedance tensor.
Figure 9. The real part of the difference of main elements of the impedance tensors, without the plan-view of models.
degrees (clockwise rotated from N-S direction). The side-anomalies in the resistivity maps give information about the current inflow- and outflow sites, while the main current streamflow is best shown by the $H_{\text{vertical}}/H_{\text{horizontal}}=0$ isolines. The author thinks that there is no need to comment the figures. The reader should feel free to look at the anomaly maps thoroughly. It is evident from the pictures, that in spite of the beauty of physical phenomena taking place in these models, it would be difficult to use these parameters as imaging tools.

The rotational invariants of the magnetotelluric impedance tensor $\mathbf{Z}$ may serve as the most compact 3-D interpretation parameters, since they do not depend on the direction of the inducing field, and they may have various morphological characteristics over 3-D bodies. Some of them reflect the model-geometry very well, some others do not so well. By using only thin-sheet modelling, it is not possible to illustrate the whole system of rotational invariants correctly. In this paper only three of them are shown: at first the skew in Figure 7, (it had been favorized so much to indicate a presence of 3-D structures, but it has proved to be completely useless in imaging them); then in Figure 8 the real part of the determinant is given, followed in Figure 9 by the real part of the difference of the main elements of the impedance tensor.

CONCLUSION AND CLOSING REMARKS

While the model-geometry in anomaly maps belonging to any field direction (Figures 1-6) cannot be seen at all, carefully selected rotational invariant maps (as shown in Figures 8 and 9) may provide a more recognizable image of the letters and numbers. The coherent test can even be read by an experienced interpreter without the help of the true planview of the letters and numbers as it is shown in Figure 9.

The thin-sheet approximation can be used only at long periods. Therefore a detailed study of 3-D responses should be based on real 3-D numerical modelling algorithms. Nevertheless, the thin-sheet approximation in estimation of 3-D magnetotelluric responses will preserve its importance as a first tool for a long time.
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