The PetRos EiKon News

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3D RESISTIVITY/IP SURVEYS WITH EMIGMA VERSION 4

*EMIGMA V4, version four of PetRos EiKon's **EMIGMA** electromagnetic simulation platform struts it's stuff!*

This summer, the *PetRos EiKon* crew have been polishing up the EMIGMA simulation platform and making improvements to the future EMIGMA V4. This issue of the *PetRos EiKon News* is a sneak preview into some of these improvements. Two literature comparisons demonstrate EMIGMA's ability to automatically generate accurate apparent resistivities using bipole-bipole surveys as well as demonstrate multi-prism systems, and multi-wire transmitters for resistivity and IP modelling.

HEADLINES THIS MONTH

- Two body bipole-bipole survey yields resistivity and IP pseudo sections.
- Wenner method depth sounding for a single layer earth.

MODEL 1 : IP/RESISTIVITY PSEUDO SECTIONS OF TWO TABULAR BODIES

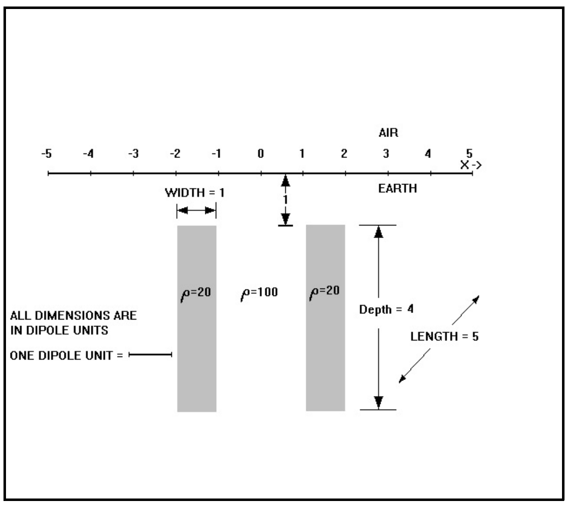


Figure 1: The IP/resistivity model from which the pseudo sections were generated. The dipole unit was chosen to be 100 for the EMIGMA runs.

The model shown in Figure 1 was taken from a paper by Hohmann[1] and consists of two parallel tabular bodies (dimensions of 1x4x5 dipole units) buried one dipole unit below the ground. The **EMIGMA** model was constructed of two prisms in a half space earth with a dipole unit (length) of 100m.

APPARENT RESISTIVITY PSEUDO SECTIONS

Six separation distances from 100m to 600m were used to generate the pseudo section apparent resistivities of Figure 2a. On a simple 486-DX2 computer, using 50 sample points per prism, the total calculation was completed in approximately 10 minutes. **The whole calculation could be done in one run because the apparent resistivities are generated by EMIGMA automatically, and EMIGMA V4 can automatically step through multiple separation distances.**

[1]*Investigations in Geophysics No. 4,* ***Induced Polarization, Applications and Case Histories*** *©1990 by Society of Exploration Geophysicists.*p154

Hohmann's solutions are presented in Figure 2b. The full solution includes interactions between the prism while the superposition solution which simply adds the first order terms from each scatterer. EMIGMA matches the full solution of the literature when the array is outside of either prism. In the region between the two prisms, the non-interacting solutions are similar to those of EMIGMA.

IP Response Pseudo Sections

Hohmann generated the IP responses using the dilution factor, B_2, rather than Cole-Cole parameters or a complex resistivity. The dilution factor is defined as

$$B_2 = \frac{\partial \log \rho_{sys}}{\partial \log \rho_{body}} = \frac{d\rho_{sys}}{\rho_{sys}} \times \frac{\rho_{body}}{d\rho_{body}} = \frac{PFE_{sys}}{PFE_{body}},$$

or more practically, as

$$B_2(\%) = 100 \times PFE_{sys} = 100 \times \frac{\Delta\rho_{a_{sys}}}{\rho_{a_{sys}}} \times 100,$$

if $\Delta\rho_{a\ body}$ is selected so that PFE_{body} is one. The IP responses, therefore, were not generated directly by **EMIGMA V4**, but were calculated from data from the original apparent resistivity pseudo section, and data from a second run where the resistivity of the bodies was perturbed slightly as required by the dilution factor model. Again, outside the region between the bodies, the agreement between **EMIGMA** generated data and the full solution literature values is excellent. Agreement in the central region is not so good. This is probably due to how the simulation was done[2].

DEFINITIONS

APPARENT RESISTIVITY

EMIGMA calculates apparent resistivity by dividing the measured potential by the current and multiplying by a geometric factor which is calculated for any array geometry.

$$\rho_{apparent} = \frac{V}{I} g.$$

PERCENT FREQUENCY EFFECT (PFE)

A measure of the change in fields due to change in frequency.

$$PFE = \frac{\Delta\rho_a}{\rho_a} \times 100$$

[2]The dilution factor is the derivative of the ratio of the logs of the apparent resistivities, this was only *simulated* by perturbing the model, and in the central region, where the components of the fields have high gradients, this is not a reliable method. Also, as with any modelling software, the assumptions that are used to digitize the fields will vary from program to program will cause differences in areas where field variation is strong.

MODEL 2: DEPTH SOUNDING WITH A BIPOLE-BIPOLE WENNER ARRAY

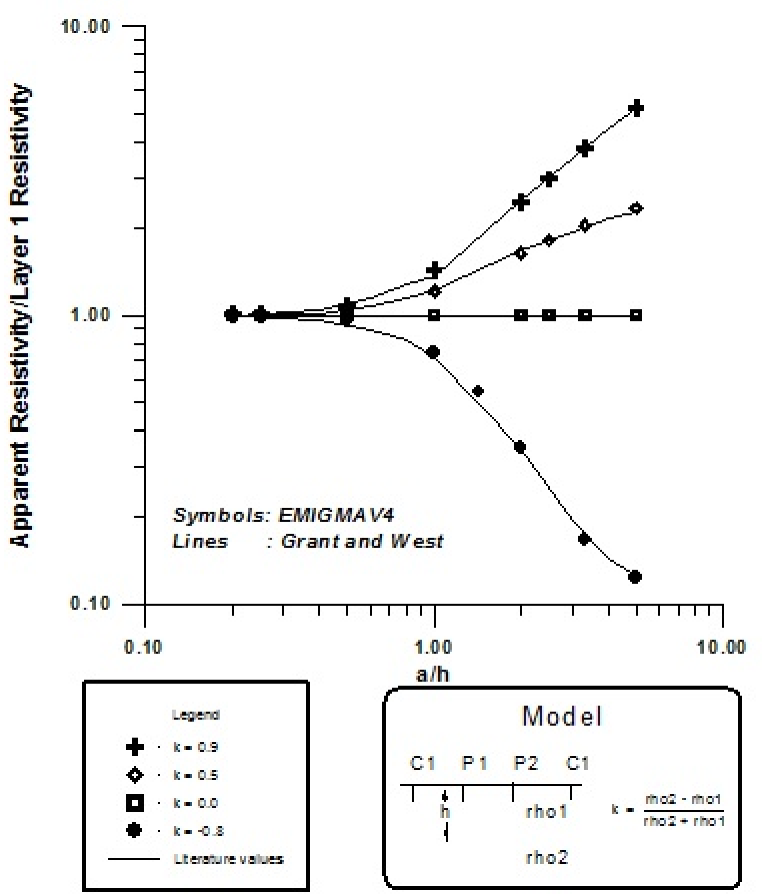
The ability to build multi-wire electrodes is demonstrated by a depth sounding model[3]. A three wire transmitter and a one wire receiver Wenner array were built over a two layer earth, and the depth of the upper layer was varied from two metres to 50 metres. Each of the lines on the plot (Figure 3) correspond to a different *k* value, where

$$k = \frac{\rho_2 - \rho_1}{\rho_2 + \rho_1}.$$

The value *a* in Figure 3 corresponds to the receiver length as well as the spacing between the ends of the transmitter and receiver.

The values were obtained by running **EMIGMA** once for each point and plotting the log of the ratio of the apparent resistivity to the upper layer resistivity against the log of the ratio of the dipole length to the upper layer depth. For this example, *a* was set to 10m, ρ_2 was set to 100 ohm·m, and ρ_1 was selected to make *k* equal to 0.9, 0.5, 0, and -0.8 respectively. The solid lines in Figure 3 show the literature results, the symbols represent the **EMIGMA** results. The literature results were transferred onto the plot spreadsheet from a figure in a published book, so small discrepancies are quite possibly the result of reading the data from the published graph in *Grant and West*.

Figure 3: DEPTH SOUNDING EXAMPLE



[3]This model was taken from Grant and West's *Interpretation Theory in Applied Geophysics*, page 410.