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TIME DOMAIN ELECTROMAGNETIC MIGRATION IN INEL RWMC COLD TEST PIT CHARACTERIZATION

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INTRODUCTION

The main task of the conducted research was interpretation of time domain electromagnetic (TDEM) data set acquired at the Cold Test Pit within the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering Laboratory (INEL) using Electromagnetic Migration method.

There were several publications dedicated to the development of simple and fast inversion technique for the processing of transient electromagnetic data (Eaton and Hohman, 1989; Macnae and Lamogntagne, 1987; Barnet, 1984). Majority of these papers have been based on equating the transient response, measured at the surface of the Earth, to the EM field of current filament images of the source (Nabighian, 1979).

In this paper we have developed and used a different approach to processing of transient data, based on downward extrapolation in reverse time. We call this method *the time domain electromagnetic migration* (Zhdanov et al., 1994). The technique has been developed for the transformation of the transient electromagnetic migration field into resistivity images of the vertical cross-section. We discuss the principles of electromagnetic migration and resistivity imaging and present the results of application of the method for the imaging of TDEM data set from the RWMC.

TIME DOMAIN ELECTROMAGNETIC MIGRATION

Time Domain ElectroMagnetic Migration (TDEMM) is based on the downward extrapolation of the observed electromagnetic field in the reverse time (Zhdanov, 1988; Zhdanov and Keller, 1994; and Zhdanov et al., 1994). Numerical solution of this problem is provided by an electromagnetic analog of the Relay integral. The integral formulation of TDEMM makes it possible to calculate different components of the migration electromagnetic field and their different time and space derivatives in the vertical cross-section.

The Rayleigh integral in full analogy with a seismic problem produces upgoing fields (i.e. fields propagating in the direction of the observation surface). These upgoing fields are electromagnetic analogs of the upgoing Claerbout seismic waves (Claerbout, 1985) and, consequently, can feature some properties specific of the latter. For example, for imaging geoelectrical cross-section we can use the "EM radiating-inhomogeneities"concept, analogues to exploding-reflectors concept, widely used in seismic migration. According to this concept the position of secondary sources of electromagnetic field (geoelectric inhomogeneities) can be determined by the location of the extremum of the migrated field. Furthermore, the technique has been developed for the transformation of the EM migration fields and their different components into resistivity images of the vertical cross-section. This technique is based on the fact that the magnitude of the migrated secondary field at the extremum points is proportional to the conductivity contrast at the boundary. So, we can transform the vertical maps of the migration field (computed at zero time) into the resistivity distribution. Results of the practical application of the TDEMM imaging method are presented in the next section.

INTERPRETATION OF RWMC TDEM DATA

The method has been applied for waste site characterization using TDEM data. We have processed by Time Domain Electromagnetic Migration Method (TDEMM) data obtained as a result of high density TDEM profiling survey with the Geonics EM47 along the set of profiles, intersecting INEL RWMC Cold Test Pit from the West to the East. The survey was conducted in the transmitter offset or slingram mode as described in (Mac Lean, 1993.)

As a result of processing of TDEM data by migration method we have obtained the set of vertical cross sections of the Cold Test Pit. These data have been interpolated in the horizontal planes to plot the horizontal maps of the resistivity distribution on the different depth: 2, 3, 4, 5, 6, 7, 8 and 9 meters. We constructed the 3D resistivity images on the basis of resistivity maps (Fig. 1 and Fig. 2). Solid line on these maps shows the known boundary of the pit. We observe on these maps several conductivity anomalies that correlate very well with the pit's sections filled with the drums and boxes.

These pictures provide a reasonable volume image of the pit. Thus the results of Time Domain Electromagnetic Migration and Resistivity Imaging made it possible to determine the vertical depth, lateral extent and anomalous resistivity of buried objects in INEL RWMC Cold Test Pit.

CONCLUSION

Time domain electromagnetic migration and resistivity imaging made it possible to outline the boundaries of the Cold Test Pit within the RWMC at the INEL on the basis of determination of the major conductive zones, characterize the distribution of the anomalous conductivity which depends on the contents of various pits. The migration apparent resistivity maps indicate the thickness of capping as well as the base elevation of the pits.

References

Barnet, 1984	Barnett, C.T., 1984, Simple inversion of time-domain electromagnetic data: Geophysics, 49,, 925-933.
Claerbout, 1985	Claerbout, J.F., 1985, Imaging the Earth Interior. Blackwell Sci. publ.,Oxford.
Eaton and Hohman, 1989	Eaton, P.A. and Hohman, G.W., 1989, . A rapid inversion technique for transient electromagnetic soundings: PEPI, 53, 384-404.
Mac Lean, 1993	Mac Lean H.D. 1993, Time domain electromagnetic survey of three waste burial pits at INEL Radioactive Waste Management Complex, TTP AL 911201-G2, Chem-Nuclear Geotech, Inc.

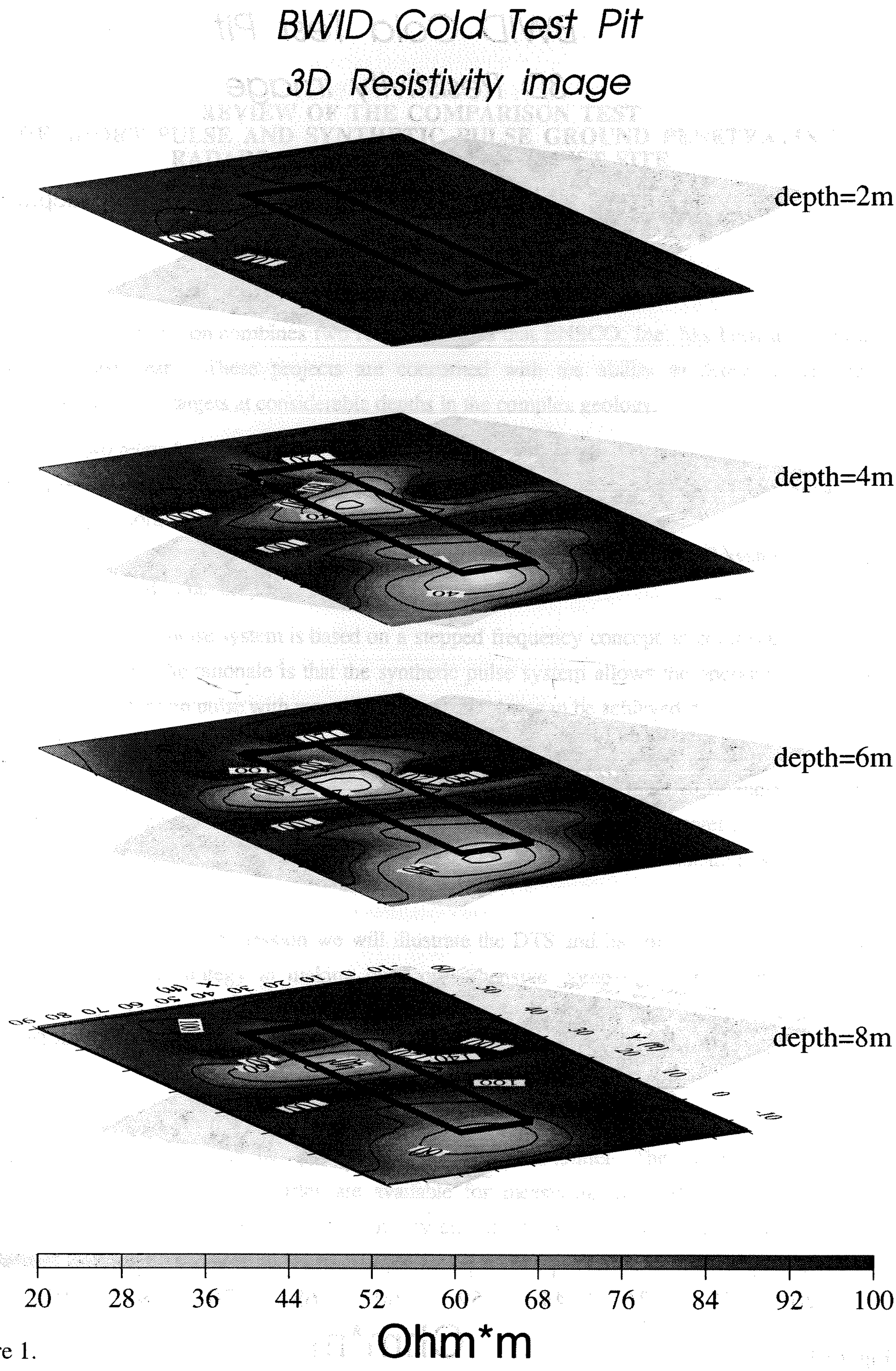
Macnae and Lamogntagne, 1987 Macnae, J., and Lamontagne, Y., 1987, Imaging quasi-layered conductive structures by simple processing of transient electromagnetic data. Geophysics, 52, 545-554.

Nabighian, 1979 Nabidhian, M.N., 1979, Quasi-static transient response of a conducting half-space - an approximate representation. Geophysics, 44, 1700-1705.

Zhdanov, 1988 Zhdanov, M.S., 1988, Integral transforms in geophysics, Springer.

Zhdanov and Keller, 1994 Zhdanov, M.S., and Keller, G.V., 1994, The Geoelectrical Methods in Geophysical Exploration. Elsevier, Amsterdam.

Zhdanov et al., 1994 Zhdanov, M.S., Traynin, P. and Booker, J.R., 1994, Principles of Electromagnetic Migration (submitted to Geophysics).



BWID Cold Test Pit
3D Resistivity image
depth=2m
depth=4m
depth=6m
depth=8m
X (ft)
Y (ft)
20
28
36
44
52
60
68
76
84
92
100
Ohm*m

Figure 1.

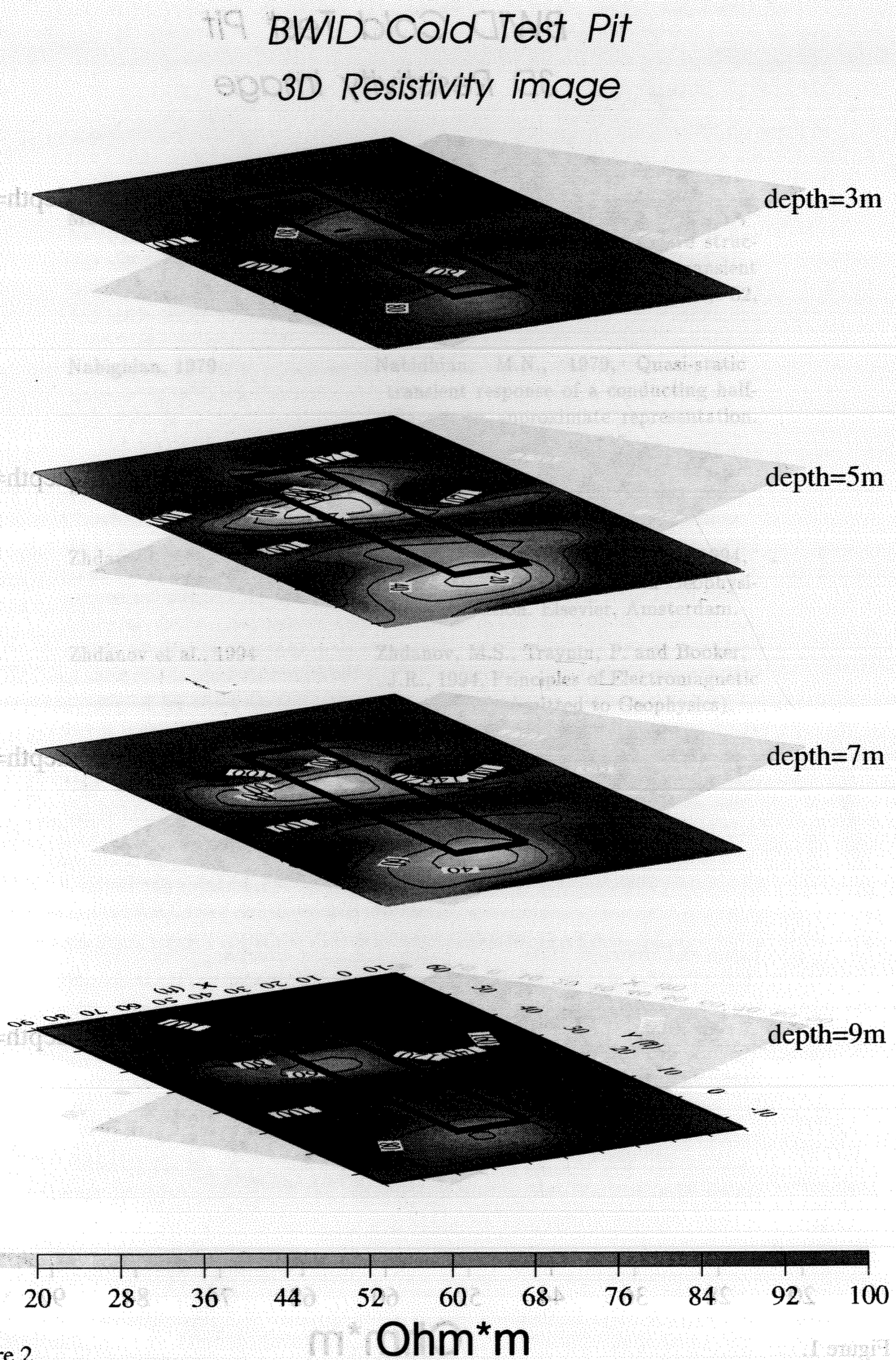

BWID Cold Test Pit
3D Resistivity image
depth=3m
depth=5m
depth=7m
depth=9m
20 28 36 44 52 60 68 76 84 92 100
Ohm*m

Figure 2.