Sandia National Laboratories

Environmental Field Geophysics

3-D Electromagnetic Imaging

Need

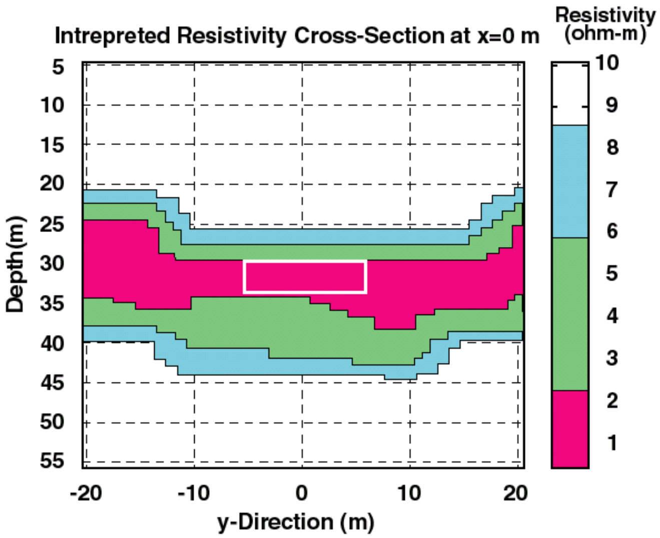
Non-invasive techniques are becoming increasingly important for shallow subsurface characterization of environmental sites. Risks associated with drilling include spreading of contaminants and generation of additional hazardous waste from drilling operations. Drilling the large number of boreholes needed for characterization and monitoring is also an expensive procedure. There is significant potential for geophysical imaging, particularly using electromagnetic techniques, to play an important role in non-invasive characterization and monitoring.

Description

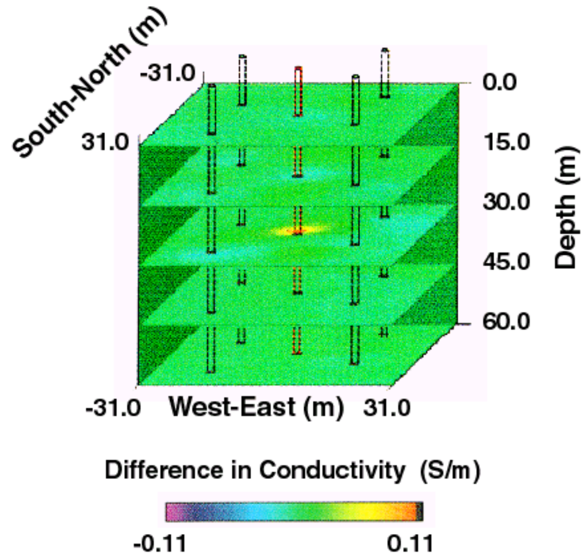
Sandia National Laboratories has developed a number of different approaches to imaging the shallow subsurface in three dimensions using electromagnetic data, and has applied several of these techniques to environmental-scale field data sets. These include wave migration and extrapolation methods, a holographic method, an integral wave-migration method, inversion of airborne electromagnetic data, integral equation approaches, and wideband three-dimensional inversion using finite-difference forward modeling, implemented on a massively parallel computing platform. These various techniques have advantages and disadvantages depending on the type and density of data collected, the type of information desired from the inversion, and the available computational resources. Integral equation methods work well for compact bodies embedded in a layered medium, but are not sufficient for more complex models. As another example, the holographic method does not reconstruct the full conductivity structure, only relative variations, but it is computationally efficient. As model complexity grows, so do the computational requirements of the technique needed to invert the data for three-dimensional structure.

Environmental Field Examples

Bartel (1997) used an integral wave-migration method to invert vertical electric source borehole-to-surface and cross-borehole data collected at a fuel oil spill at the Sandia National Laboratories site in Livermore, CA. Diesel fuel was spilled into the unsaturated zone from a puncture of a feed line to an above-ground storage tank. Bartel found a resistivity anomaly near the location of the spill site. Alumbaugh and Newman (1997) applied their massively parallel 3-D electromagnetic inversion scheme to crosswell vertical magnetic dipole data (VMD) collected at the Richmond Field Station in Berkeley California. This experiment imaged a zone of injected salt water meant to mimic environmental contamination. By separately inverting VMD data taken before and after the salt water injection and then looking at the



Cross-section image of a resistivity anomaly at a fuel oil spill site at Sandia/California



3-D image of salt-water plume obtained from inversion of electromagnetic data

difference between the two inversions, they produced an accurate image of the salt water plume.

References

Alumbaugh, D. L., and G. A. Newman., Three-dimensional massively parallel electromagnetic inversion – I. Analysis of a crosswell electromagnetic experiment, Geophys. J. Int., 1**28**, 355 - 363, 1997.

Bartel, L. C., Electromagnetic imaging of a fuel oil spill at Sandia/CA, SAND97-0914, Sandia National Laboratories, Albuquerque, NM 87185, 1997.

Newman, G. A. and D. L. Alumbaugh., Three-dimensional massively parallel electromagnetic inversion – I. Theory, Geophys. J. Int., **128**, 345 - 354, 1997.

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