Spectral Induced Polarization

Non-Invasive Characterization of Contaminant Plumes.

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Principal Investigators

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Overview

This research project is aimed at improving our understanding and applications of all aspects of spectral IP as applied to the mapping and characterization of contaminant plumes. There are four distinct tasks:

1. Laboratory measurements and interpretation of time and frequency domain IP characteristics. Microgeometric and chemical influences have been tested.
2. Development of 3D/2D spectral IP modeling and inversion codes.
3. Review of current field data acquisition methods in an attempt to make improvements.
4. Application of the developed methodology to one or more field sites.

Publications

Frye, K.M., D.P. Lesmes, and F.D. Morgan, 1998, The influence of pore fluid chemistry on the induced polarization response of rocks and soils, SAGEEP Proceedings, pp. 771-781.

Shi, W., W.L. Rodi, and F.D. Morgan, 1998, 3-D induced polarization inversion using complex electrical resistivity and the induced polarization response of sandstones, SAGEEP Proceedings, pp. 795-805.

Sturrock, J.T., D.P. Lesmes, and F.D. Morgan, 1998, The influence of micro-geometry on the hydraulic permeability and the induced polarization response of sandstones, SAGEEP Proceedings, pp. 859-869.

Vandiver, Amy, 1998, Analysis of the effects of inductive coupling in induced polarization surveys of environmental contaminants, MIT B.S. Thesis.

Shi, W., 1998, Advanced modeling and inversion techniques for three-dimensional geoelectrical surveys, MIT Ph.D. Thesis.

Other Personnel

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Modeling & Inversion

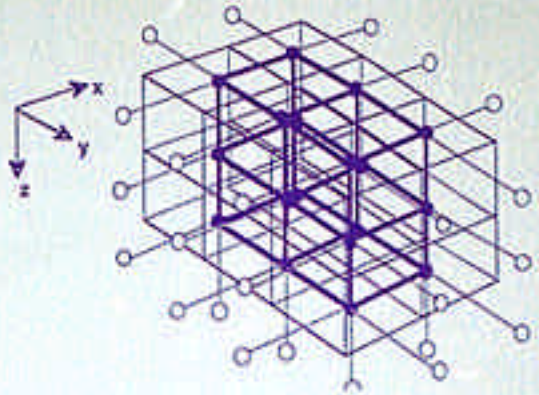
A new 3D/2D frequency domain complex resistivity or spectral IP modeling and inversion computer program has been developed. It is fast, accurate and stable. It uses a finite difference grid and the bi-conjugate gradient method for both the forward and inverse algorithms. Stability and improved accuracy is achieved in the inversion algorithm by the use of Tikhonov regularization. The objective function $\Psi(m)$, which is minimized follows:

$$\Psi(\mathbf{m}) = ||\mathbf{d} - \mathbf{G}(\mathbf{m})||^2 + \tau||\mathbf{L}\mathbf{m}||^2$$

where:

- $\mathbf{d}$ = data
- $\mathbf{G}$ = model
- $\mathbf{L}$ = Laplacian
- τ = regularization parameter
- $\mathbf{m}$ = model parameter

Discretized Subsurface Network



$$\nabla(\sigma(x,\omega)\nabla V(x,\omega)) = -I(x,\omega) \longrightarrow Kv = s$$

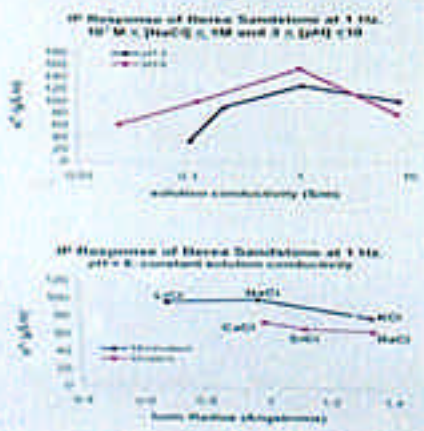
where:

- v: potential vector
- s: current vector
- K: complex, symmetric matrix

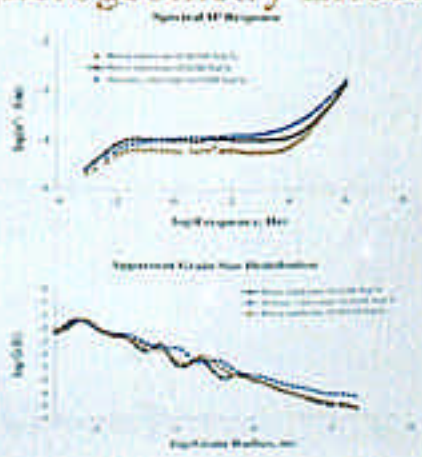
Laboratory Studies

Experiments have been conducted to study the effects of solution chemistry and microgeometry on the spectral IP response of sandstones. Results indicate that changes in chemistry affect the magnitude of the spectral IP response and changes in microgeometry affect the shape of the spectral IP response. Our physiochemical IP model can be used to invert spectral IP data for an apparent grain size distribution.

Chemistry Effects



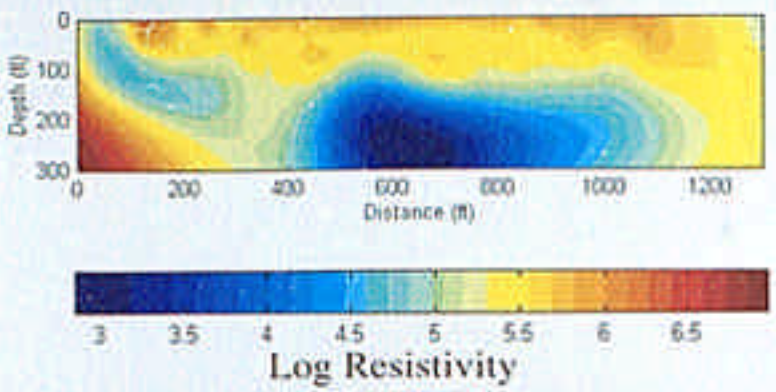
Microgeometry Effects



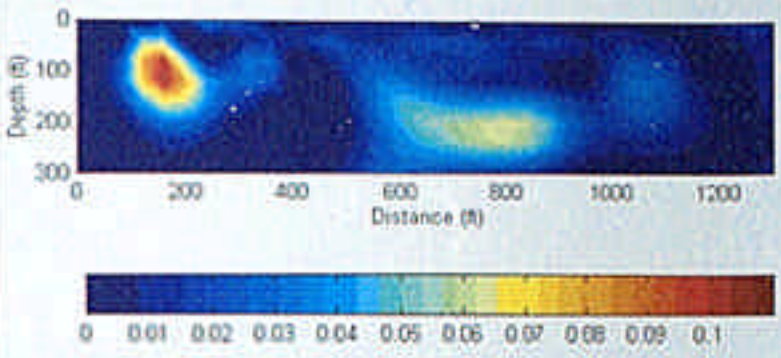
Spectral Chargeability

Field Example From FS-12 Plume (Benzene & Ethylene Dibromide Contaminants) at the Massachusetts Military Reservation, Otis ANGB

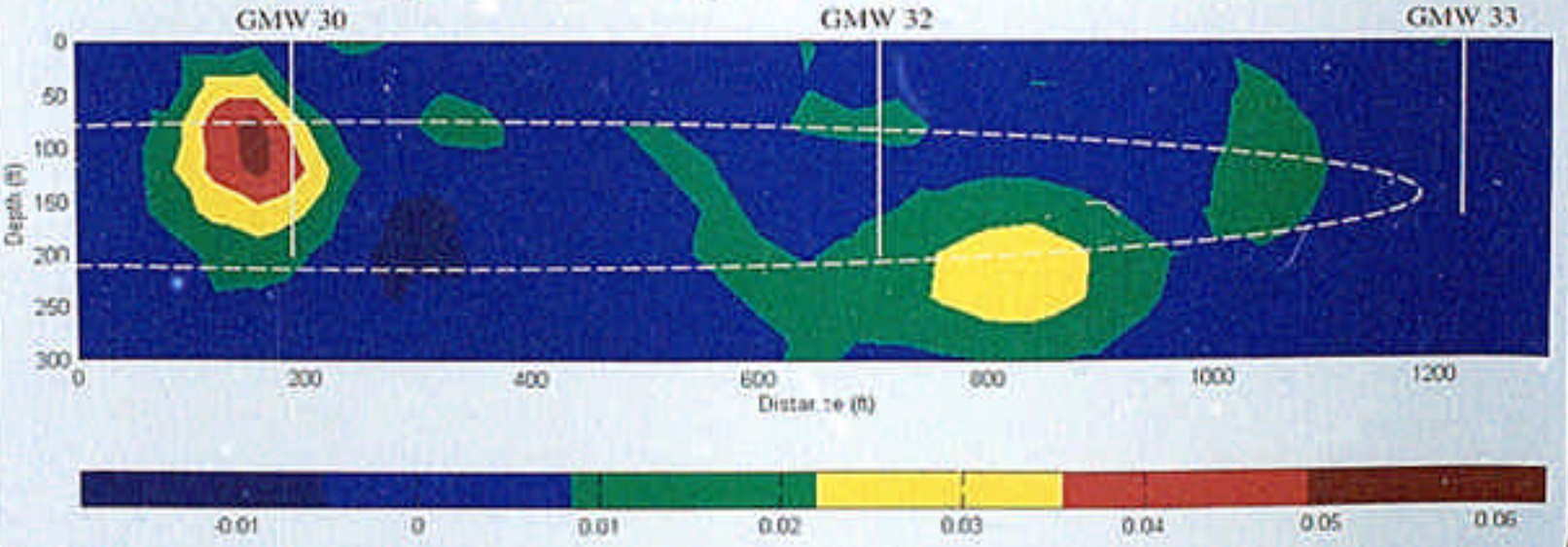
Resistivity Tomogram



Chargeability Tomogram



Spectral Chargeability Difference



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Spectral Chargeability Difference = High Freq - Low Freq