Outline

- Introduction to ZTEM
- Data Preparation
- Regional Inversion
- Deposit Scale Inversion
- Comparisons with other Methods
- Conclusions
ZTEM Technique

- Vertical magnetic fields recorded over the survey area

- Data relates the vertical magnetic field to the horizontal field at some fixed grounded reference station

- Reference station compensates for unknown source field amplitude

- Large areas can be surveyed quickly and economically

- Promising technique to find large scale structures at depth
Transfer Functions

Transfer functions relate the vertical magnetic field to the horizontal magnetic field at some fixed reference station

\[ H_z(r) = T_{zx}(r, r_0)H_x(r_0) + T_{zy}(r, r_0)H_y(r_0) \]

- Two unknowns and only one equation
- Source polarization is assumed to be random
- Use measurements from independent source polarizations

\[
\begin{pmatrix}
  H_z^{(1)}(r) \\
  H_z^{(2)}(r)
\end{pmatrix} = \begin{pmatrix}
  H_x^{(1)}(r_0) & H_y^{(1)}(r_0) \\
  H_x^{(2)}(r_0) & H_y^{(2)}(r_0)
\end{pmatrix} \begin{pmatrix}
  T_{zx} \\
  T_{zy}
\end{pmatrix}
\]
Controlled vs Natural Source
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- Magnetic source drops off as $1/r^3$
- Sources must be installed and maintained by field personnel
- Multiple transmitters can provide high quality datasets with potentially thousands of different sources to illuminate the earth.
  - Very conductive targets can saturate response.
  - Resistive targets may not induce response above the noise floor
- Source strength and frequency/waveform is known
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  - Very conductive targets can saturate response.
    Resistive targets may not induce response above the noise floor
- Source strength and frequency/waveform is known
- Natural sources have no geometric decay – deep penetrating plane waves
- Sources are naturally occurring
- Source amplitude and direction are unknown
- Can only survey when there is sufficient signals at desired frequencies.
Virgin River ZTEM Survey

Data collected April, 2009

30 lines, 310 line-km of data

30, 45, 90, 180, 360 Hz

600,000 data

Invert dataset for regional and deposit scale structure

Invert using ZTEM3D code
(Holtham and Oldenburg GJI 2010)
Depth of Investigation

Skin depth for Sandstone

- 30 Hz : 4.3km
- 360 Hz : 1.2km

Skin depth for Metapelites

- 30 Hz : 3.2 km
- 360 Hz : 900m
Complex 3D Inversion: Workflow

1. Obtain the data
2. View and understand the data
3. Obtain topography
4. Discretize, validate forward modelling
5. Determine background model for inversion
6. Assign uncertainties
7. Invert each frequency individually
8. Evaluate Inversion results
   - Incorporate additional information
9. Simultaneously invert all data
10. Evaluate results
    - Final Result
Understanding the Regional Data

Simple current interpretation will give approximate distributions of conductors and resistors

90 Hz, Real part. Electric Field perpendicular to the lines
Simple current interpretation will give approximate distributions of conductors and resistors

90 Hz, Real part. Electric Field perpendicular to the lines
Data Preparation

Export the data from the Geosoft database

Geotech data convention is that Hx, Hy are defined along line and perpendicular to the lines.

Convert the data into the UBC format

Assign the uncertainties to each component. Floor plus a percentage error
Discretize the Earth: Regional Inversion

Coarse mesh: 49 x 49 x 48 (400 x 400 m cells)
Invert 30, 45, 90, 180, 360 Hz
Determine large scale structure
Base station moved closer to the core mesh
Discretize the Earth: Regional Inversion

Observed 90 Hz

Predicted 90 Hz
Regional Result (600m Depth)
Regional Result
Deposit Scale Inversion: Cross Section Across the Deposit

- 65 x 67 x 70 cells
- 125 x 105 x 30 m cells
- Invert all the frequencies
- Obtain a conductivity model near the deposit
- Compare with other conductivity models at the deposit scale
Depth Slice at ~500m
Depth Slice at ~600m
Depth ~ 800m
Conductive Cutoff
Geologic Cross Section

Dufferin Lk fault
Zones of enhanced permeability
Centennial Deposit
Reduced Fluids
Graphitic fault (conductor)

Oxidized U bearing Fluids

Unconformity

Section facing grid north

W ➔ E

500
400
300
200
100
0
-100
-200
-300
-400

VRU_08001

300m 280m

VR-022, W2 (185+00E, L10+00N)
VR-025 (186+30E, L10+00N)
VR-004 (187+70E, L10+25N)
Geologic Comparison

800m depth
600 m Depth

Magnetics

ZTEM
600 m Depth

Magnetics

ZTEM
ZTEM Conclusions

• Good technique to explore for deep unconformity type deposits
• 3D regional and local scale inversions
• Two results seem consistent and both show a strong conductor near the unconformity
• Regional results seem consistent with the potential fields data
• Deposit results seem consistent with the DC resistivity and geology.