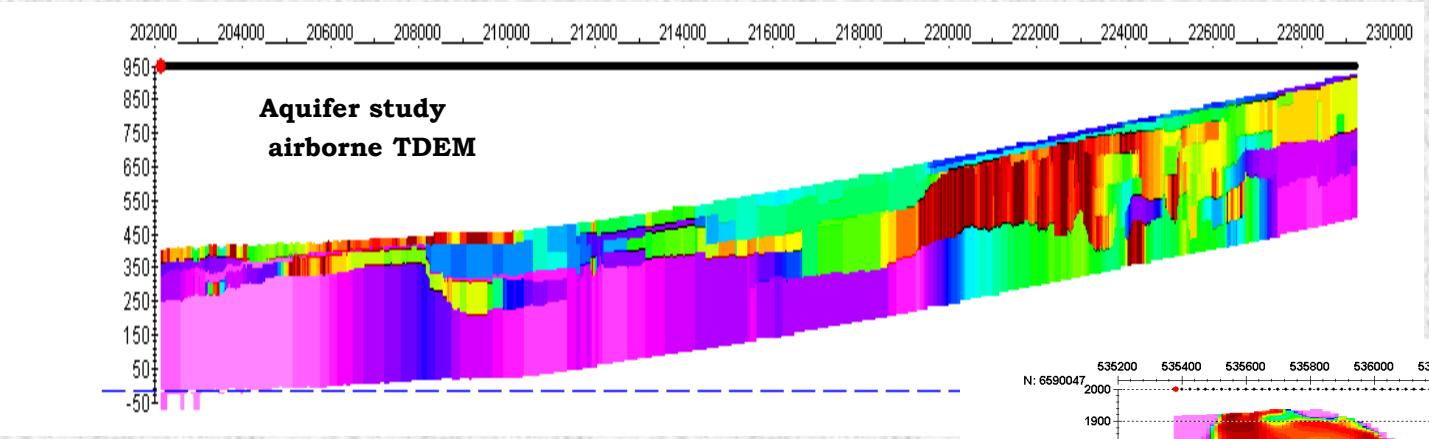
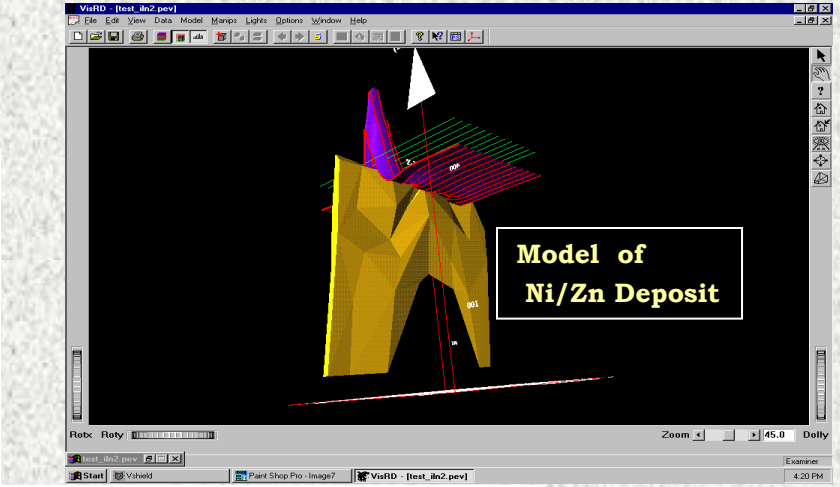
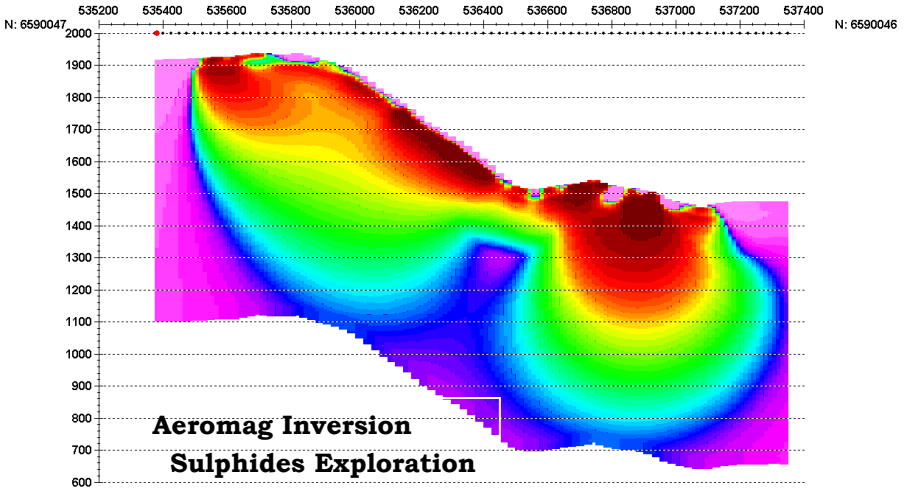
Eikon Technologies (Earth Imaging)

Software for Detection, Delineation, Exploration, Education and Quality Control







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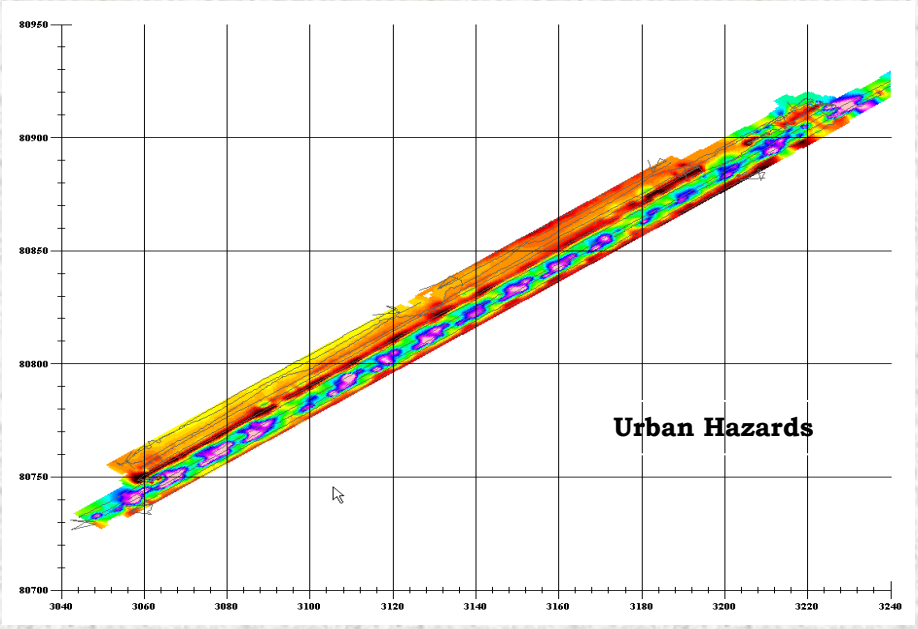
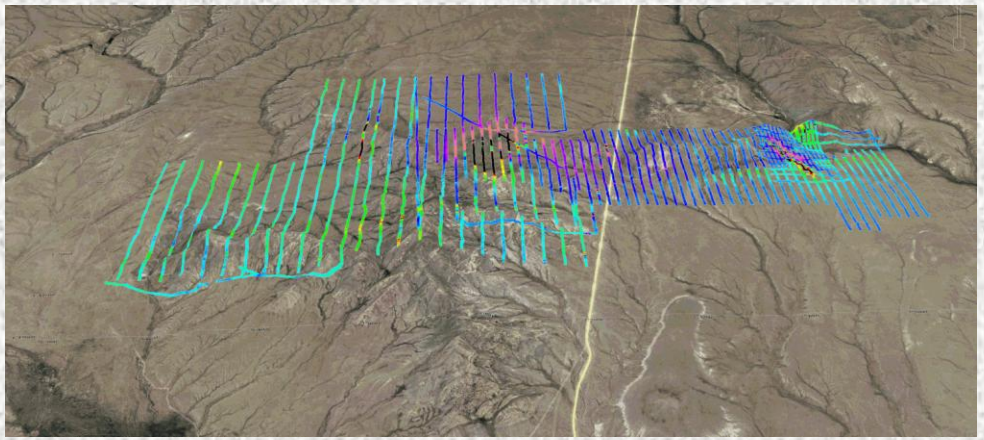
Developing Software for Interpretation of Geophysical Data Since 1994

EIKON TECHNOLOGIES

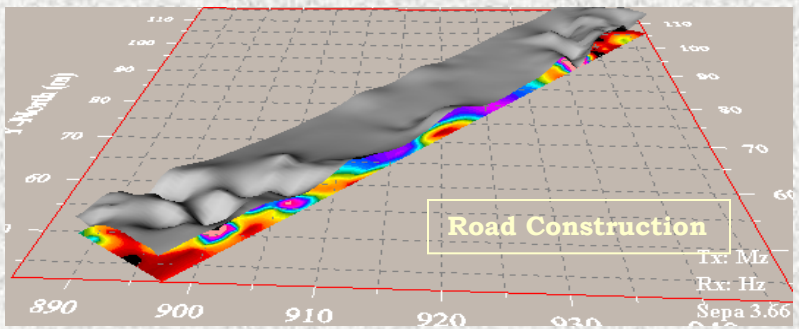




Mining Exploration

Modelling, Inversion, Data Analyses, Research

Applications

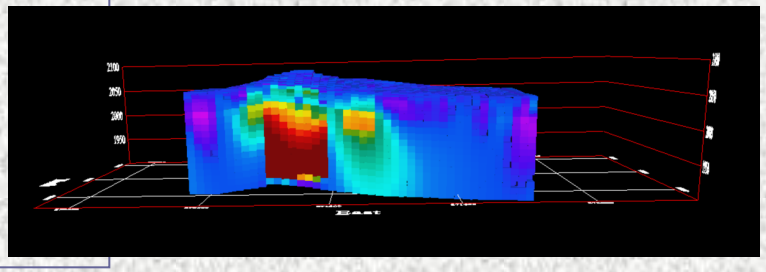


TEM
FEM
MAGNETICS
AEM
HEM
CSAMT/CSEM
IP
RESISTIVITY
GRAVITY
MT
MMR
VLF

BOREHOLE
SURFACE
AIRBORNE
CROSSHOLE

- ✓ **Mining Exploration and Delineation**
- ✓ **Environmental Detection and Monitoring**
- ✓ **Geotechnical Investigations**
- ✓ **Oil and Gas Exploration**
- ✓ **UXO**

- detect, delineate
- depth determination, spatial resolution
- survey design
- characterisation, evaluation
- research



EMIGMA Survey Capabilities

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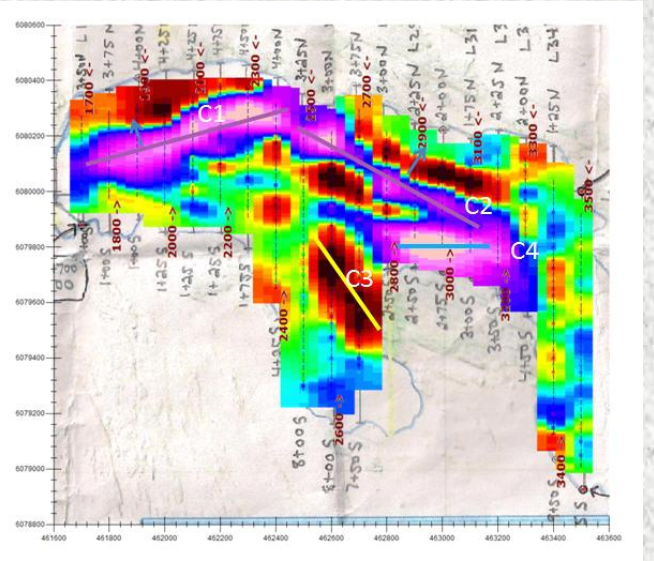
Design Aim:

All non-seismic data surveys from DC to 5 MHz!

- *Data Types*
  - *EM, Resistivity, IP, Magnetics, CSAMT, CSEM, MT*
  - *Gravity, MMR, VLF, VLF-R, MTEM*

Survey Styles

- *surface*
- *airborne*
- *surface to borehole*
- *borehole to borehole*



* not all combinations available

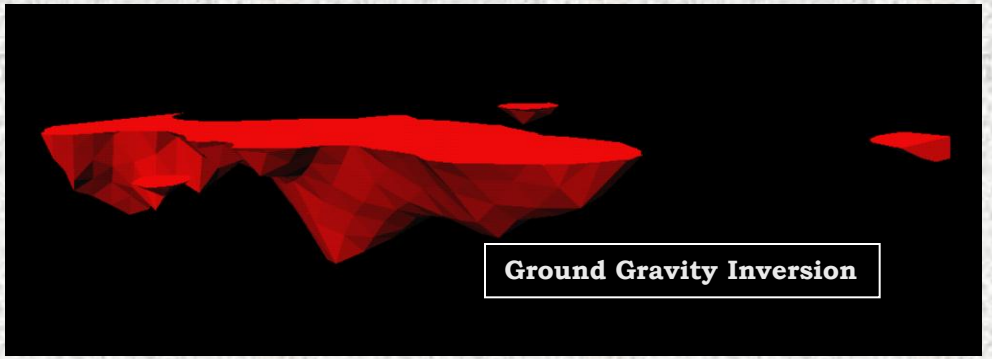
Data analyses and editing tools

EMIGMA Tools

3D Visualization
3D Model Building
CAD Model Imports (from other applications such as AutoCAD, Surpac and Vulcan)

3D Data Simulation – instrument calibrated – Magnetics, Resistivity, Gravity, EM, IP, MT, CSAMT, CSEM, VLF, MMR

3D Magnetic Inversion, 3D Euler, 2D Wenner
3D Resistivity Inversion
3D TDEM, FDEM thin–sheet inversions
3D MT Inversion, CSAMT, land-based CSEM Inversion, ZTEM
1D FEM, TEM, Resistivity, CSEM, MT, CSAMT Inversions
FDEM, TDEM, Resistivity Pseudo-Depth and Geoelectric Sections



Data Processing, Filtering and Editing
1D Digital and Spatial filters, 2D spatial filters
Advanced Interpolation and Gridding Tools
- rectangular grid elements, multi-component grids
- gradient griddling, non-planar girding, constant drape

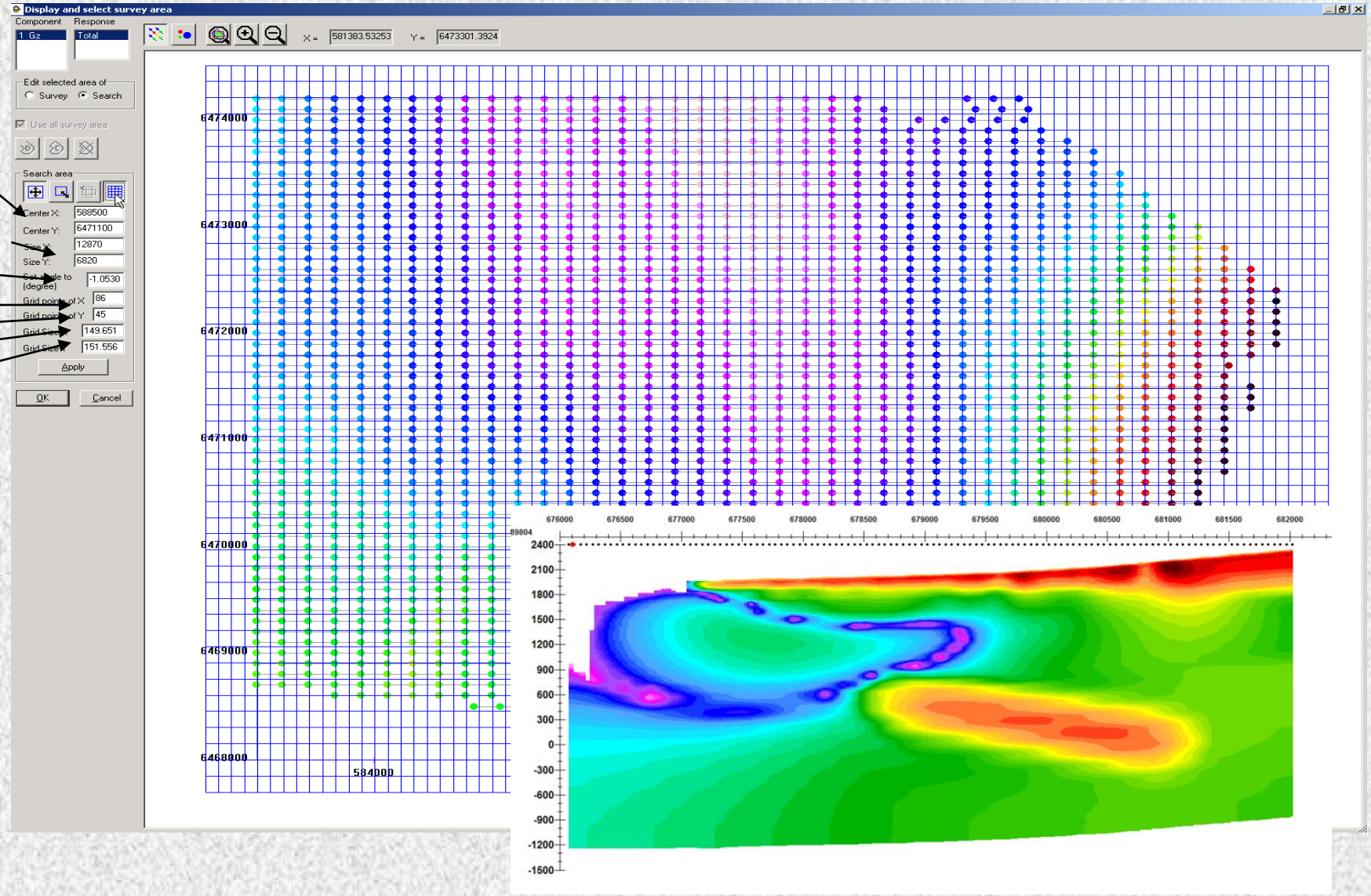
Model Stripping
Potential field data transforms – filtering, continuation, RTP
Magnetic and Gravity Gradients
Magnetic Compensation
Xhole Tomography

Gravity – 3D Modeling and Inversion
3D Euler and Post-Processing including 3D Visualization
FFT tools

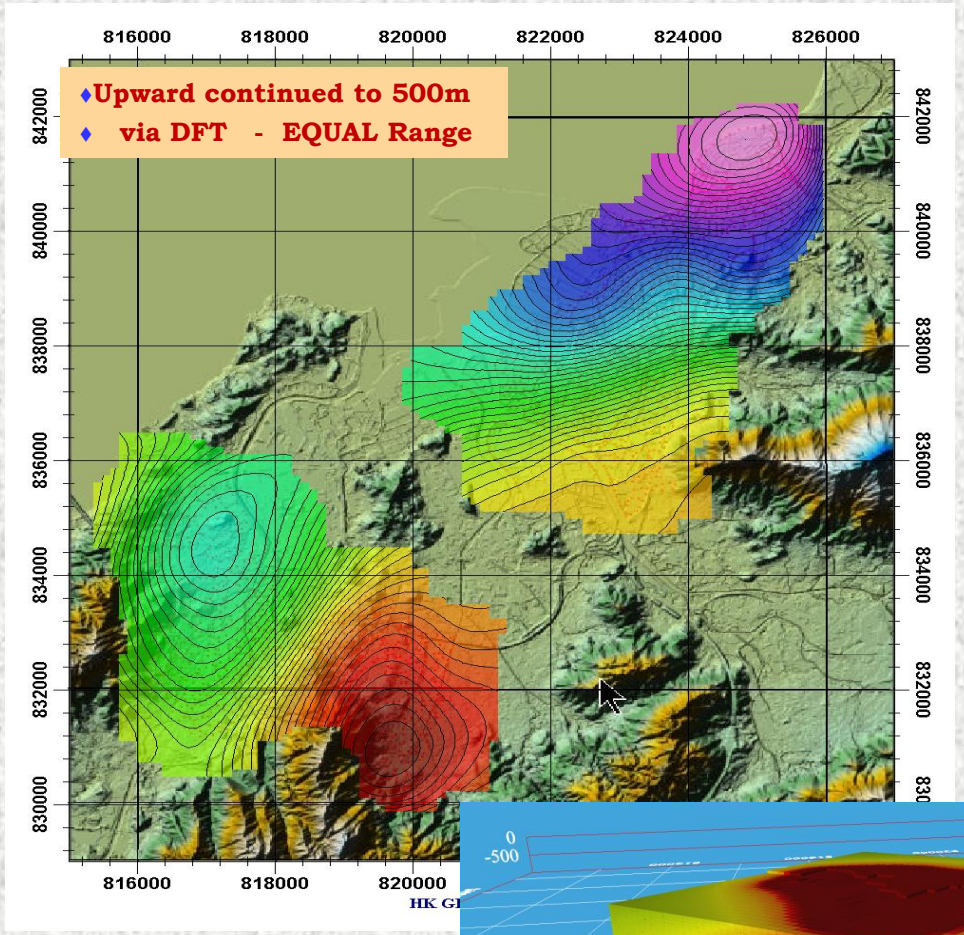
the data may be shown and the interface allows the user to define the inversion or “search” grid

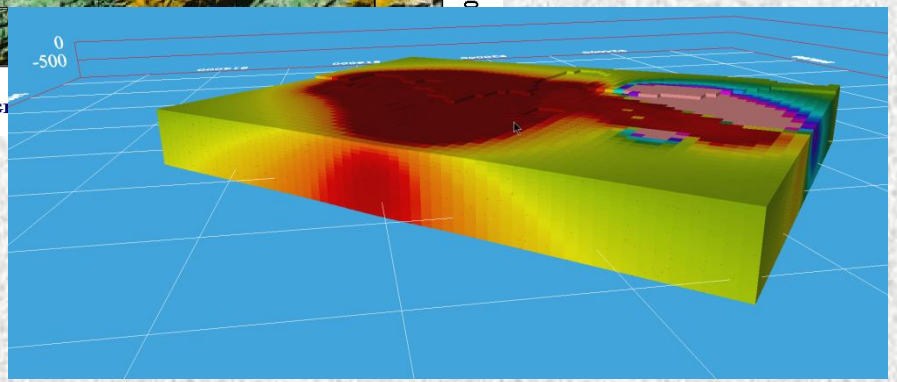
centre of XY-grid

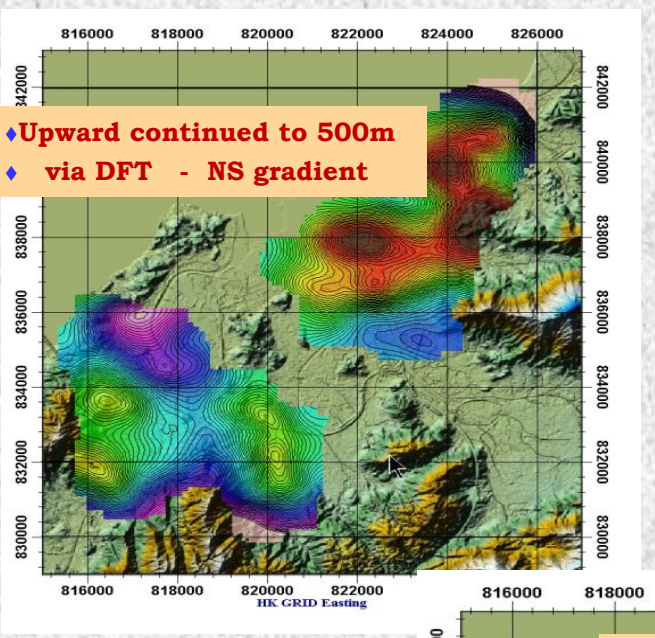
total size of XY-grid
angle of grid
Nx in grid
Ny in grid
dX in grid
dY in grid

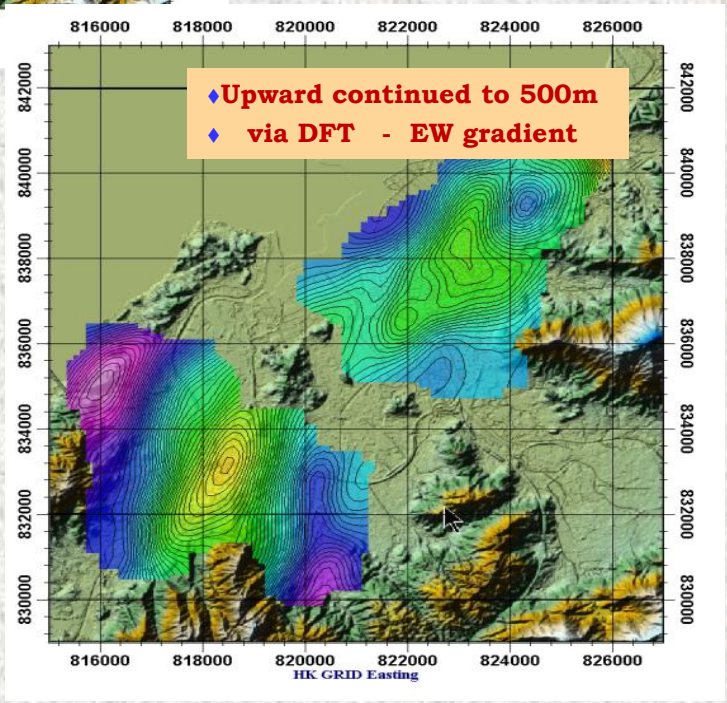


Fourier Processing and Inverse Applications







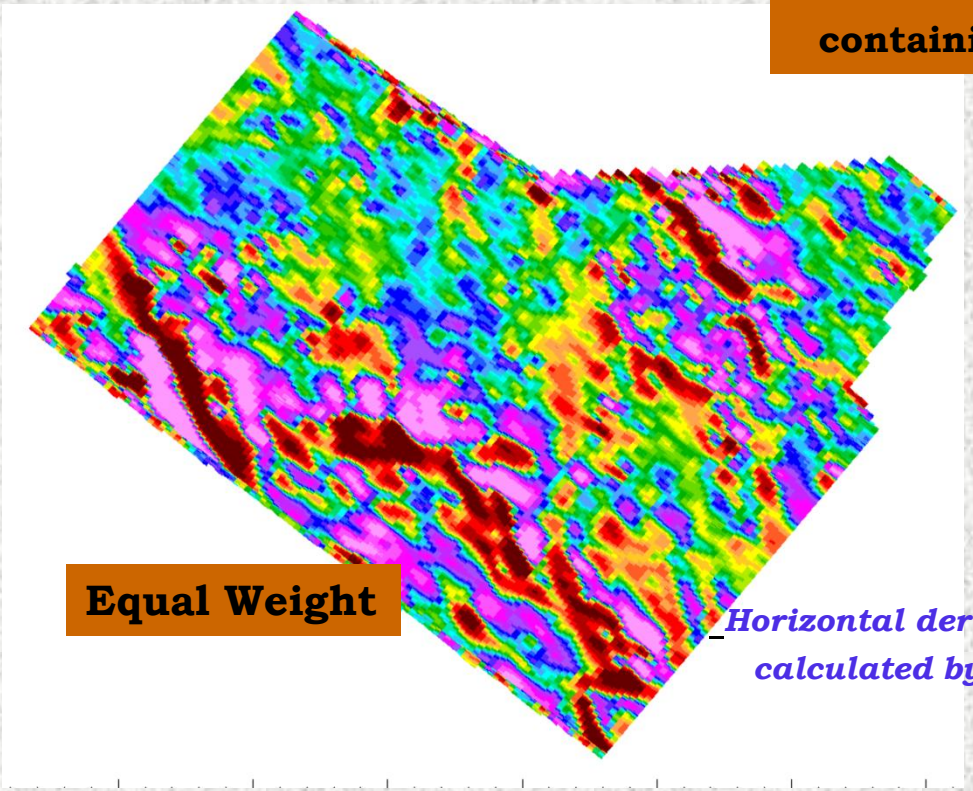


Data Interpolation and Contouring 1

Local - Natural Neighbour, Shepard, Delaunay
Global Splines -Minimum Curvature

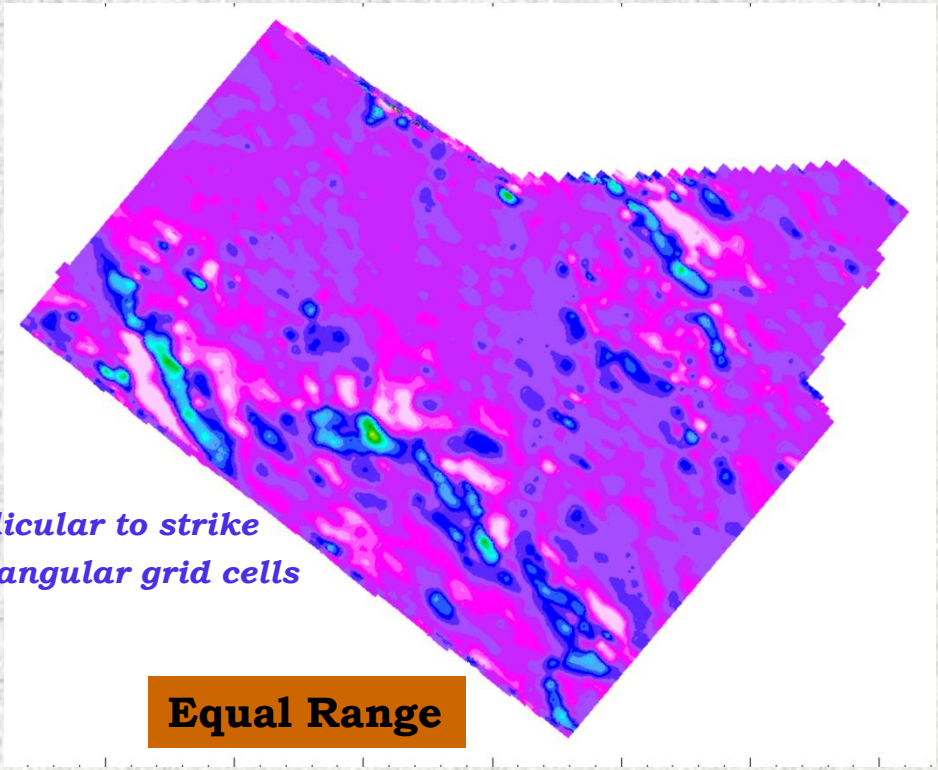
Multi-Dimensional Grids

containing multiple time windows, frequencies and components



Equal Weight

Horizontal derivative perpendicular to strike
calculated by DFT with rectangular grid cells



Equal Range

Rectangular grid cells

providing enhanced resolution especially for derivatives

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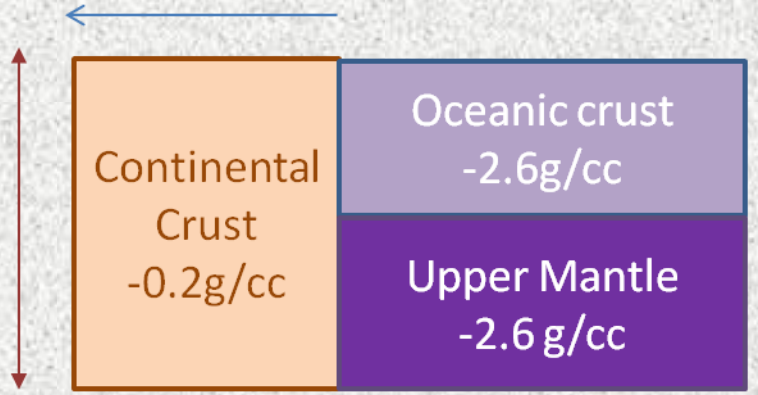
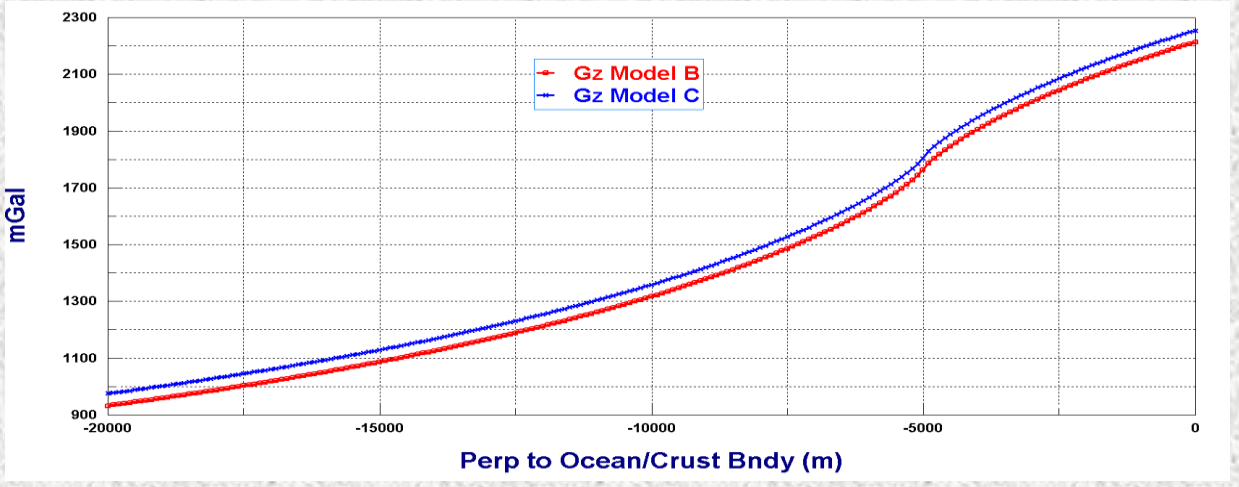
Gravity Modeling 1

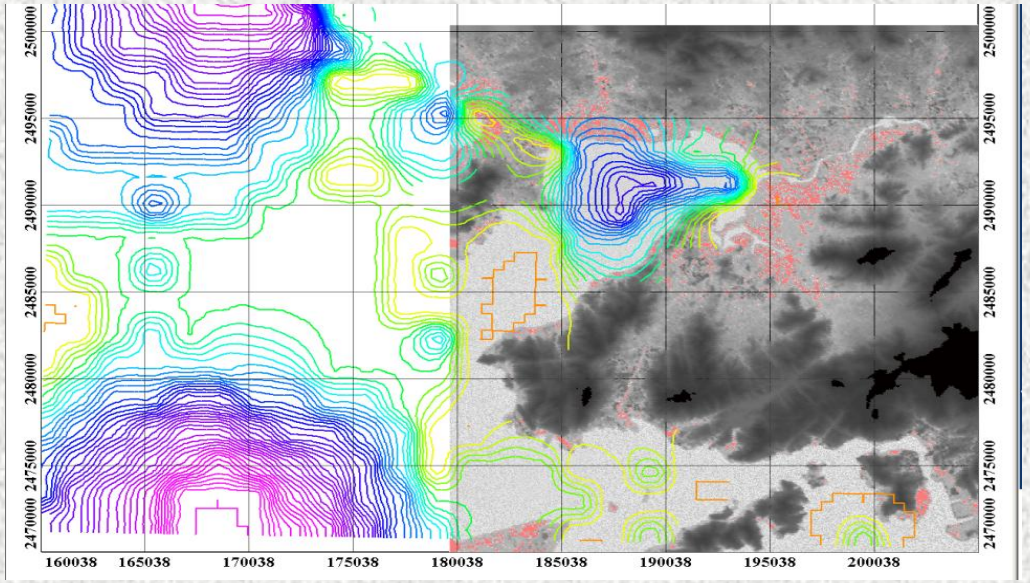


Model B

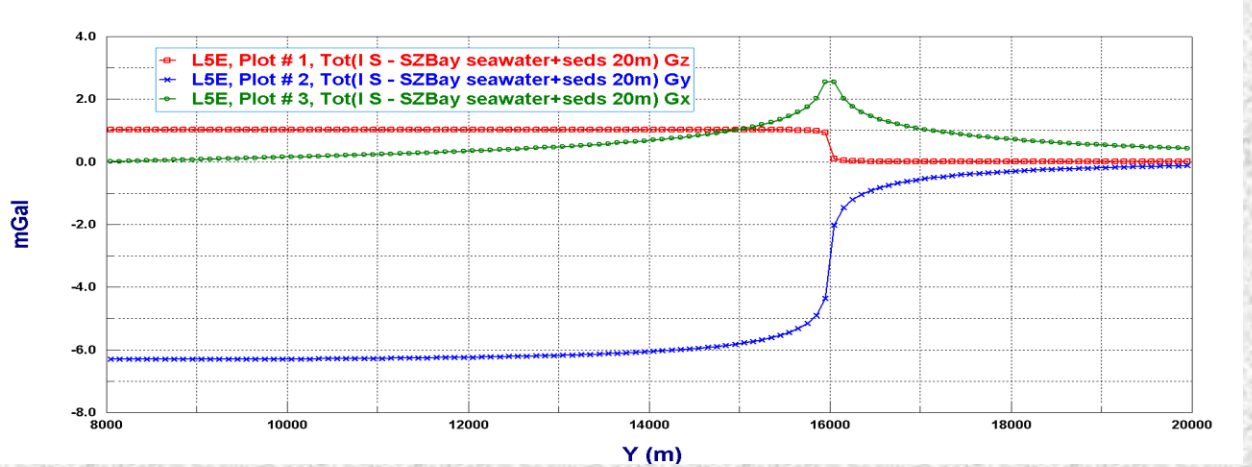
Inland Effects of Oceanic Crust and Upper Mantle



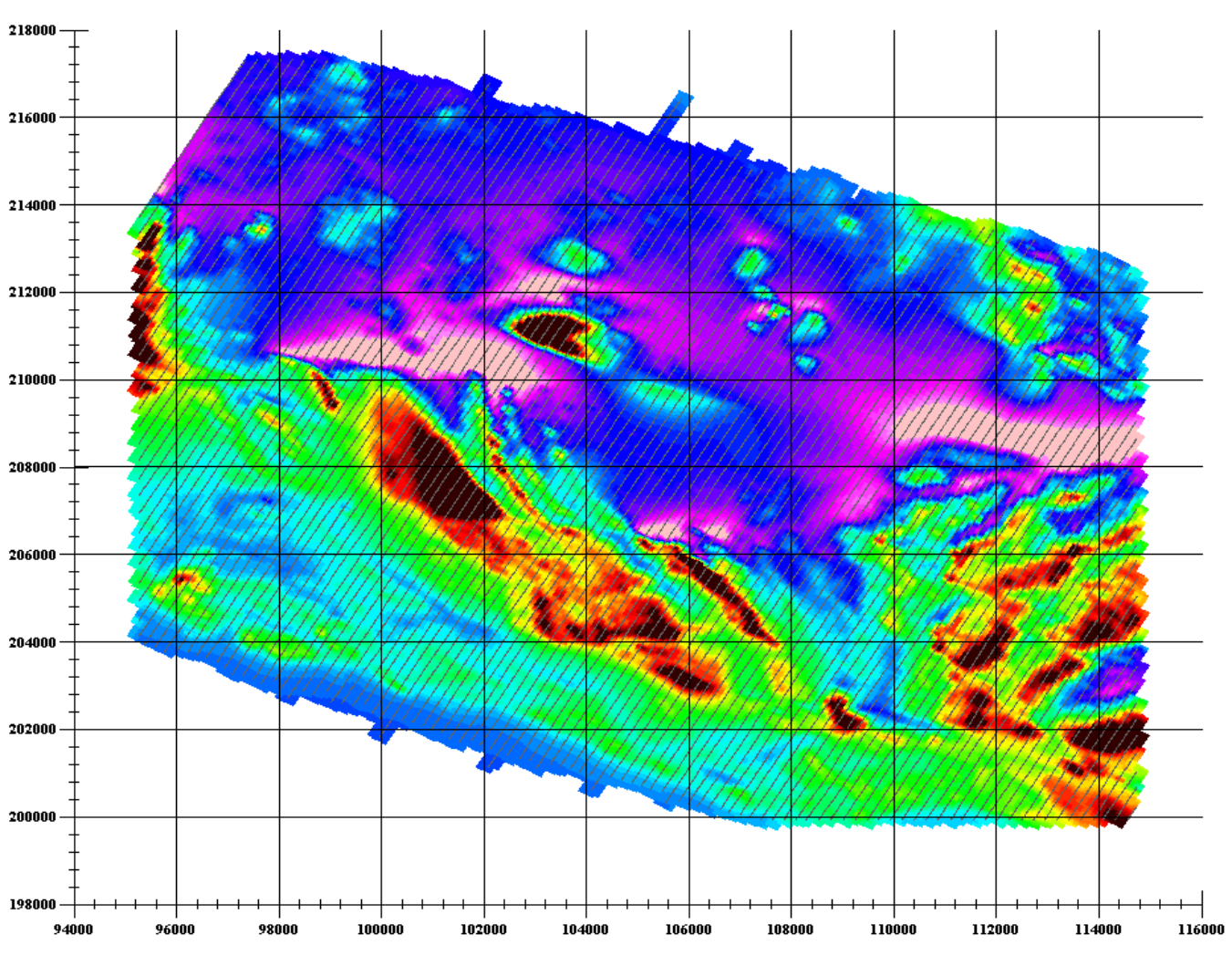
Gravity Modeling 2



Effects of Seawater and Sediments

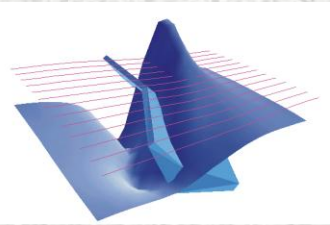


Data Interpolation and Contouring 2

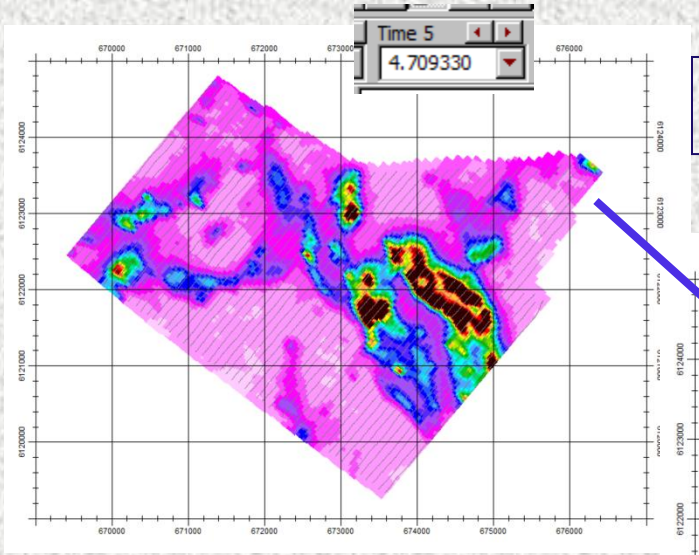


Massive Sulphide Exploration – Spain/Portugal

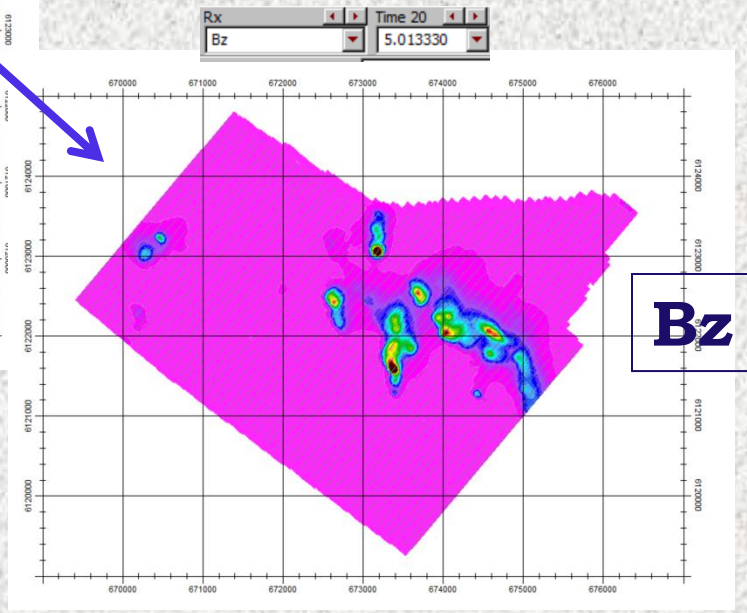
- ✓ Natural Neighbour Interpolation
- ✓ Delaunay Triangulation
- ✓ Shepard
- ✓ Minimum Curvature
- ✓ Splines



Track anomaly time evolutions with the click of a button

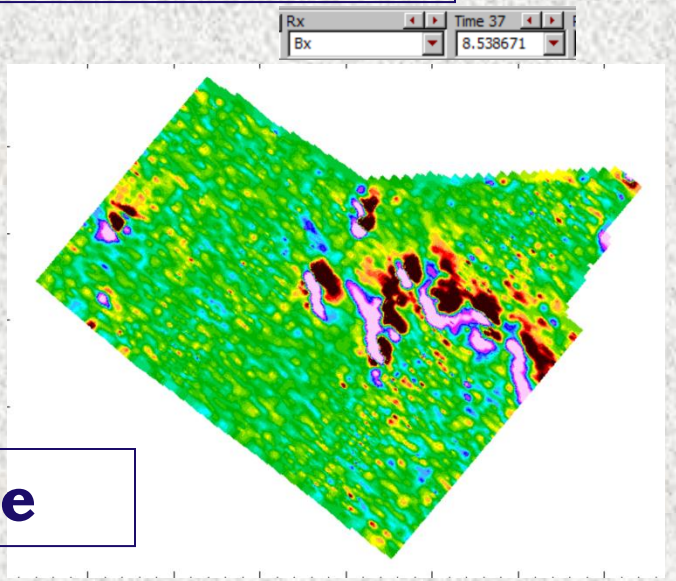


Early TEM Bz



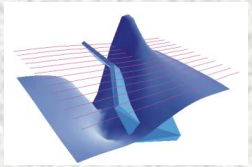
Track anomaly time evolutions with the click of a button

Bz Mid-Time

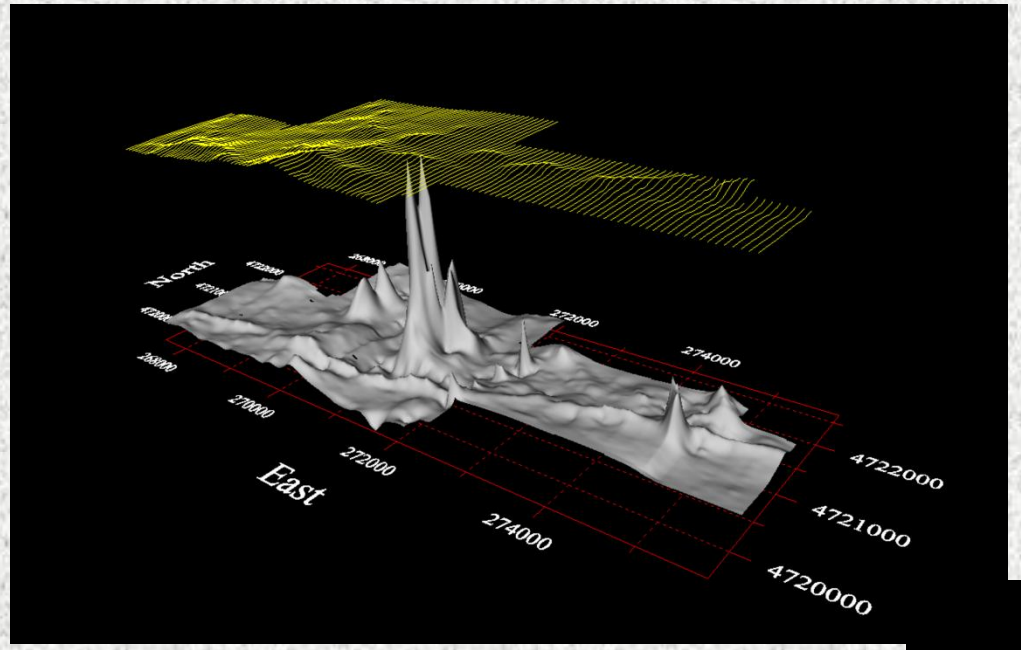


All time windows and components stored in one grid file linked with the data by database functionality.

Bx Late-Time

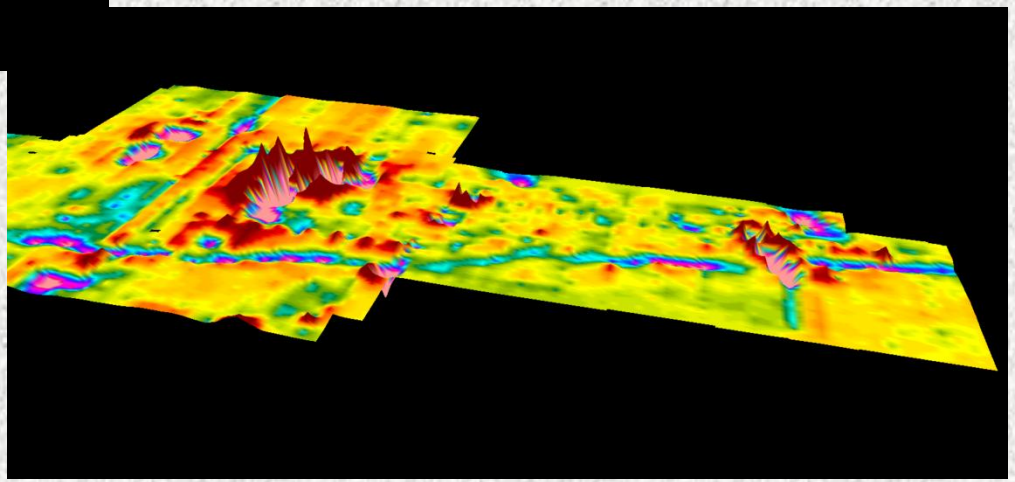


Surface representation of data allows for a spatial display of anomalies



TMI

VMS Exploration US



Vertical Derivative TMI

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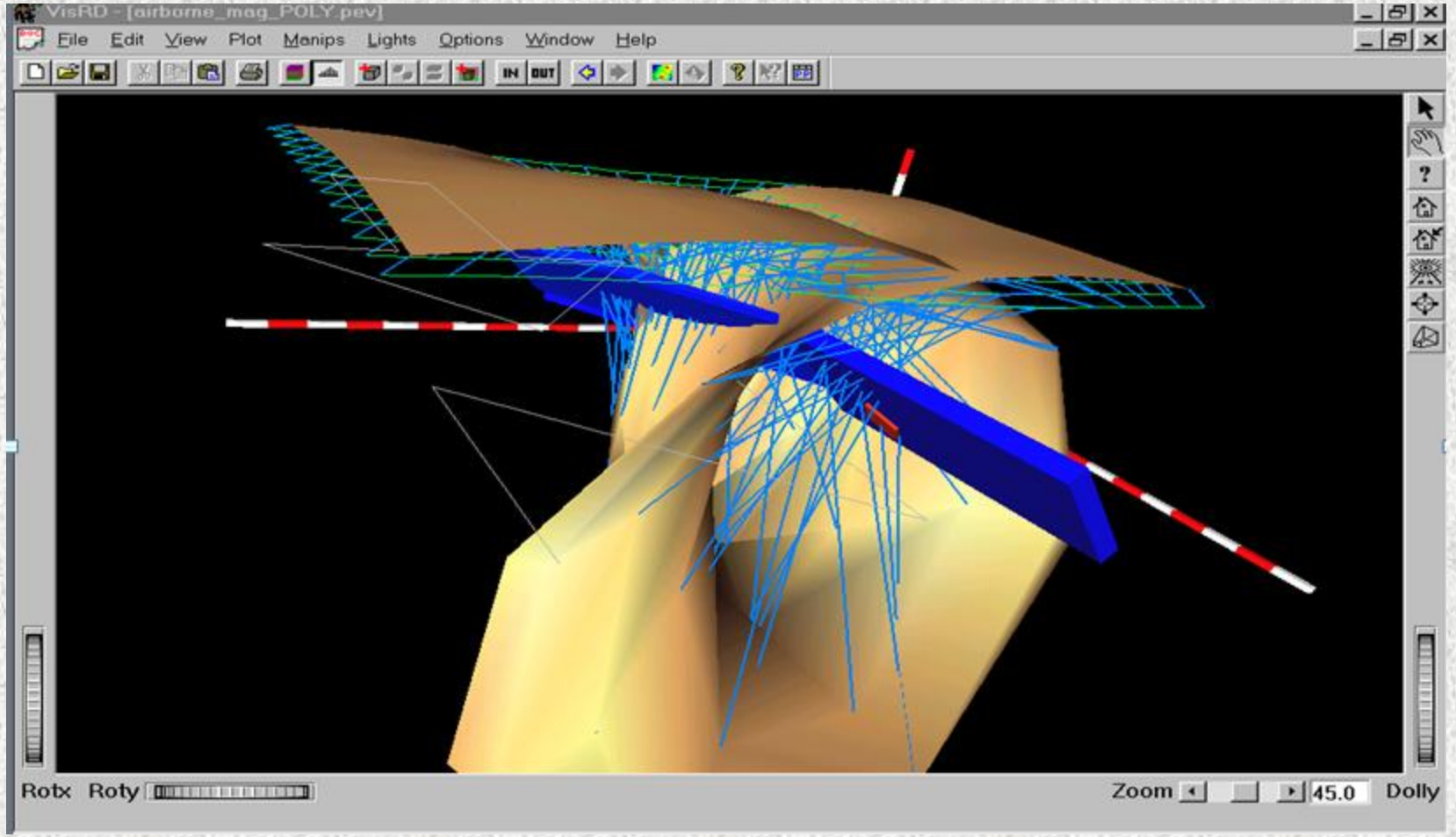
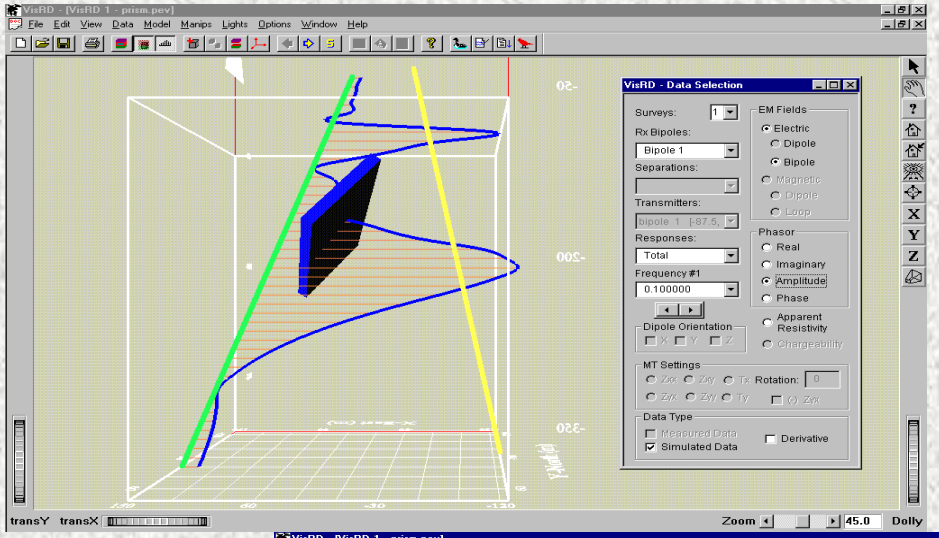
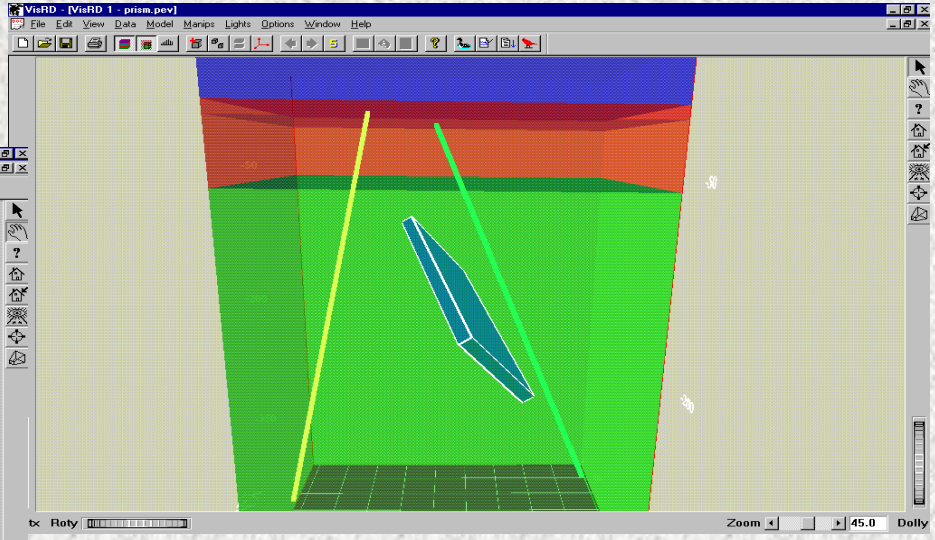
A Range of 3D Data Representations

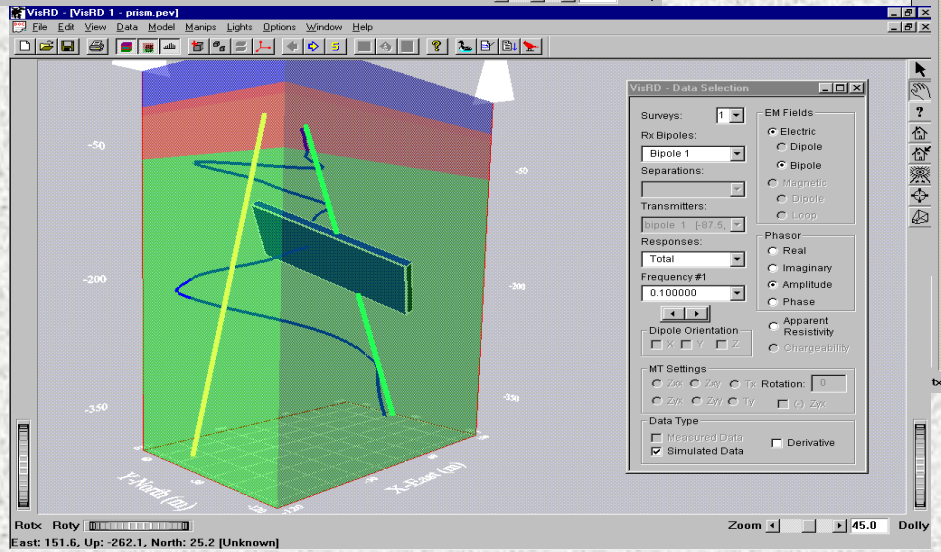


Model Building and Simulation - 1



View survey, Build models and analyze data in 3D





***e.g.* Crosshole resistivity survey and model – gold deposit delineation**

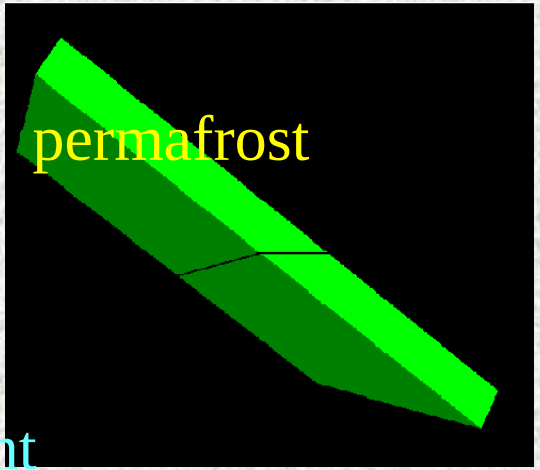
Model Building and Simulation - 2

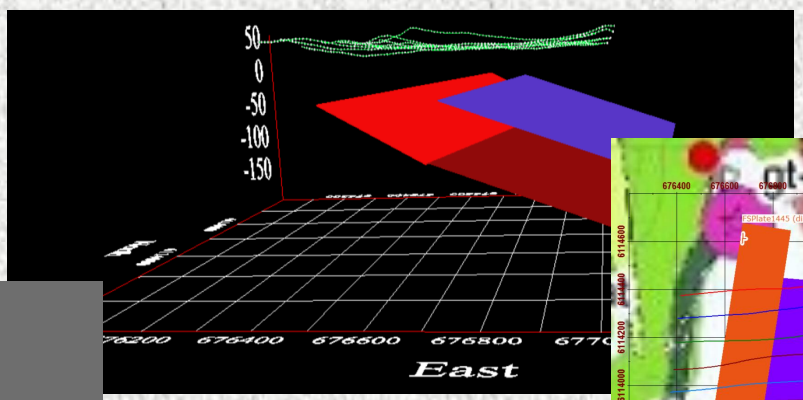
EM –> TDEM and FDEM

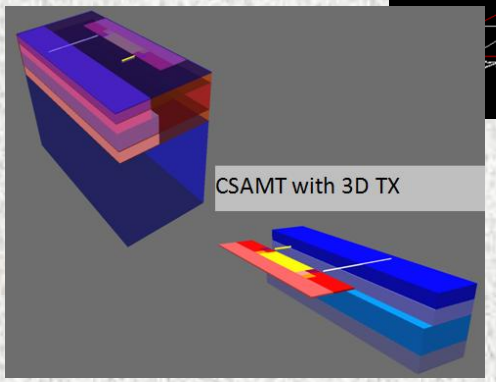
-- 3 Algorithms – 2D/3D integral equations in layered host

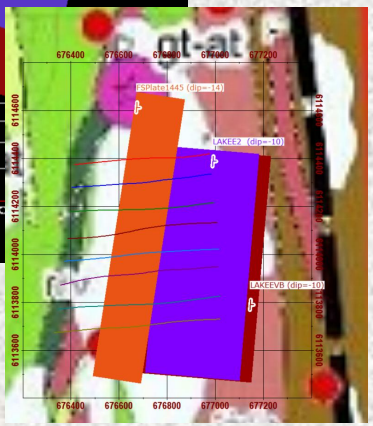
+ 2 Thin Sheet and 1 Spherical Harmonics algorithms

- Prisms, Plates, ***Spheres*** and Polyhedra
- Strong and Weak Interactions
- Industry defined and theoretical current Waveforms
- Airborne, Ground and Borehole
- Fixed, Moving and Stepwise Moving Transmitter
- Magnetic effects – magnetostatic, inductive, galvanic
- IP effects
- direct comparisons to measured data
- super-engine multi-processing
  architecture for large models or surveys
- Model Suites
- Batch modelling
- ***Thin Sheet Plate Inversions***









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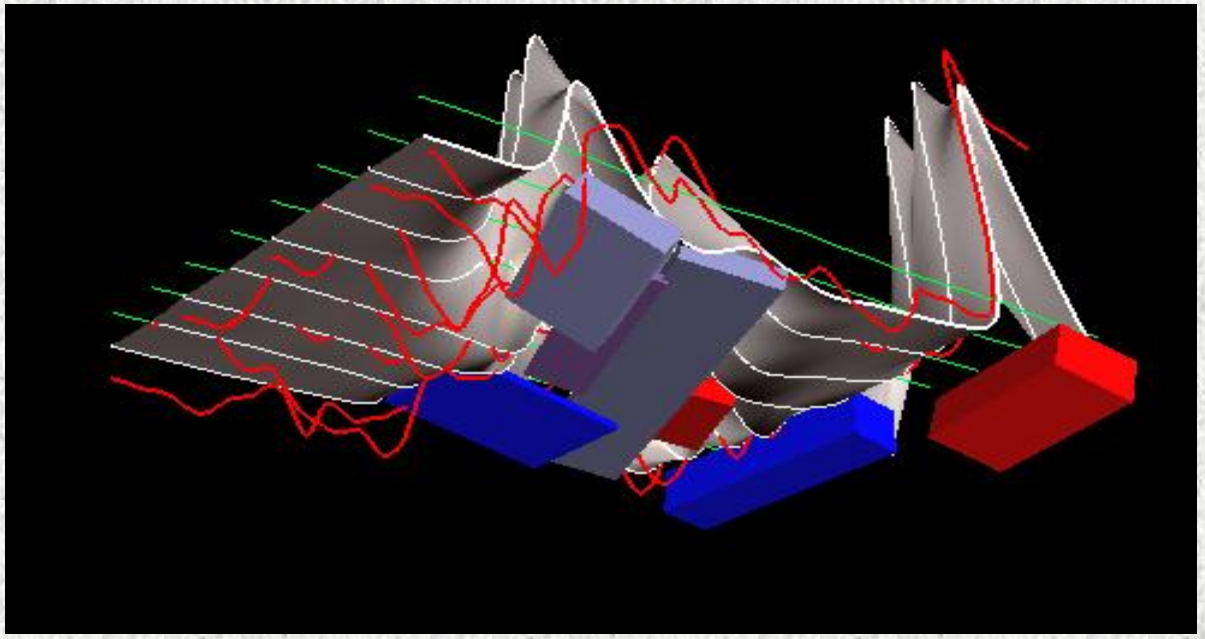
Model Building and Simulation - 3

Pb/Zn exploration
Helicopter FEM

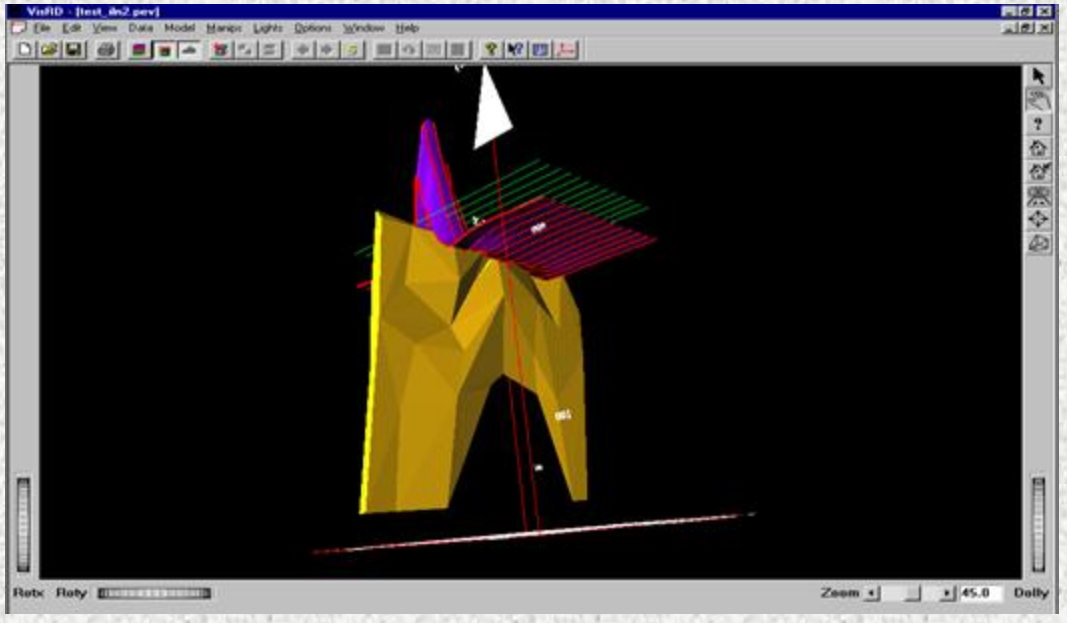


Magnetics

- 3 Algorithms – 3D integral equation
  Born (weak), Strong (non-linear), Permanent
- Prisms and Polyhedra
- Strong and Weak Interactions
- Airborne, Ground and Borehole
- Gradients (up to 2nd order)
- 3-axis (i.e. Components)
- direct comparisons to measured data
- super-engine architecture for large models or surveys

UXO cleanup

Model Building and Simulation - 4



IP/Resistivity/MIP

- 3D integral equation
  Born (weak) and Strong (non-linear)
- Prisms , Polyhedra, Sphere
- Strong and Weak Interactions
- TDEM and FDEM
- EM effects in IP (e-field pickup effects of current wires)
- Full contrast between host and bodies
- Ground, Surface to Borehole, Borehole to Surface, borehole to borehole
- direct comparisons to measured data
- PseudoSections and depth imaging tools
- super-engine architecture for large models or surveys

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Model Building and Simulation - 5

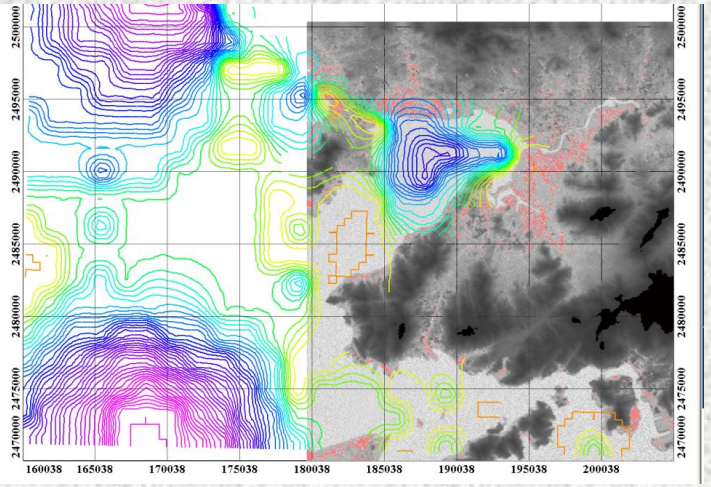
Gravity – 3D

analytic solutions and traditional numerical integration

– Total field, gravity components,

gravity gradients to 2nd order tensors

airborne, ground, underground and borehole surveys



Gravity response of seawater plus sediments

MT, CSEM/CSAMT (3D)

-impedances for MT/CSAMT

- field responses for CSEM

– full current wire response (not just dipole sources)

Strong and Weak Interactions between anomalies

Crosshole

electric (3 antennae types) or magnetic antennae

Experimental Systems

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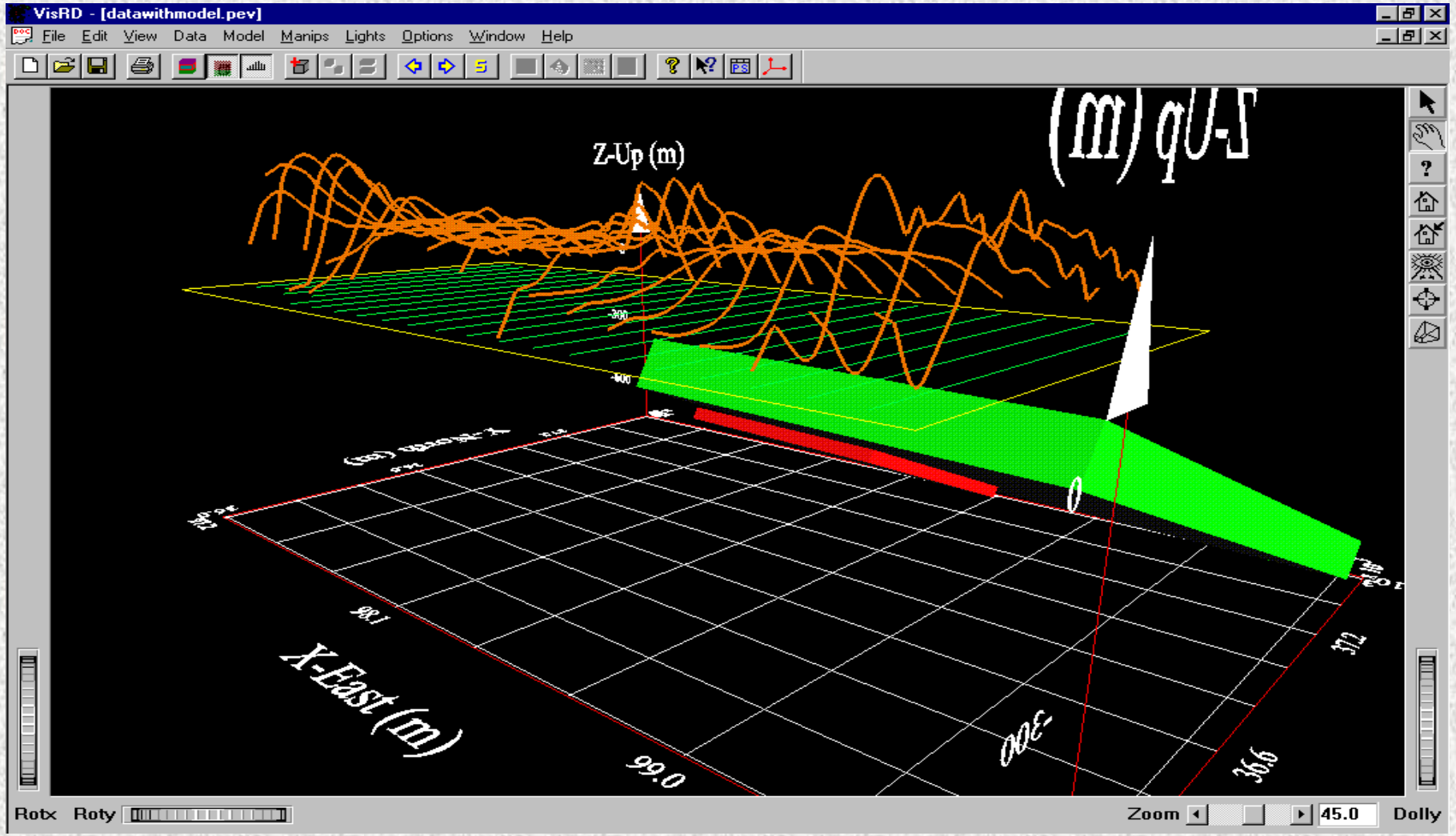
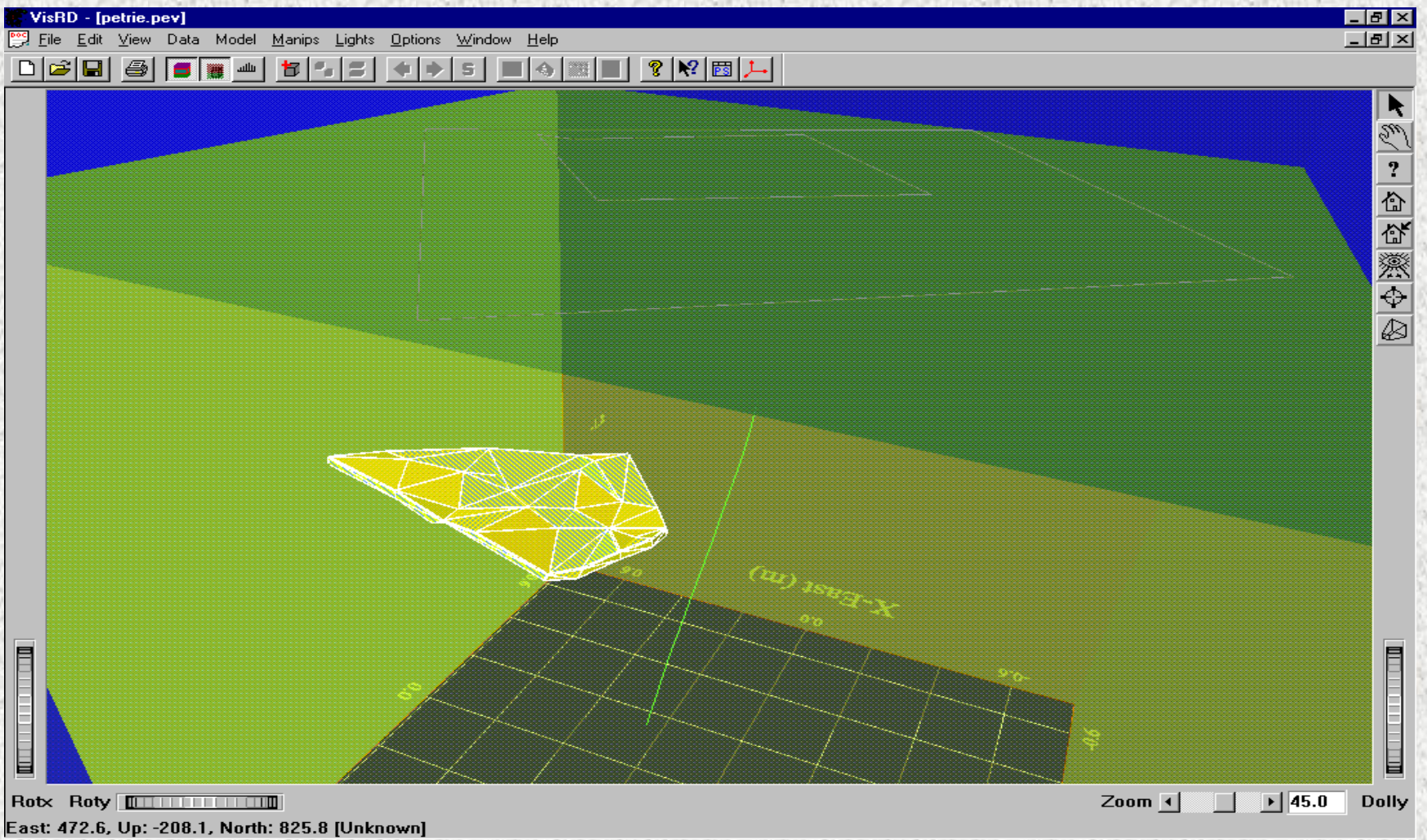
Data and Structure Representation in EMIGMA's 3D Visualizer



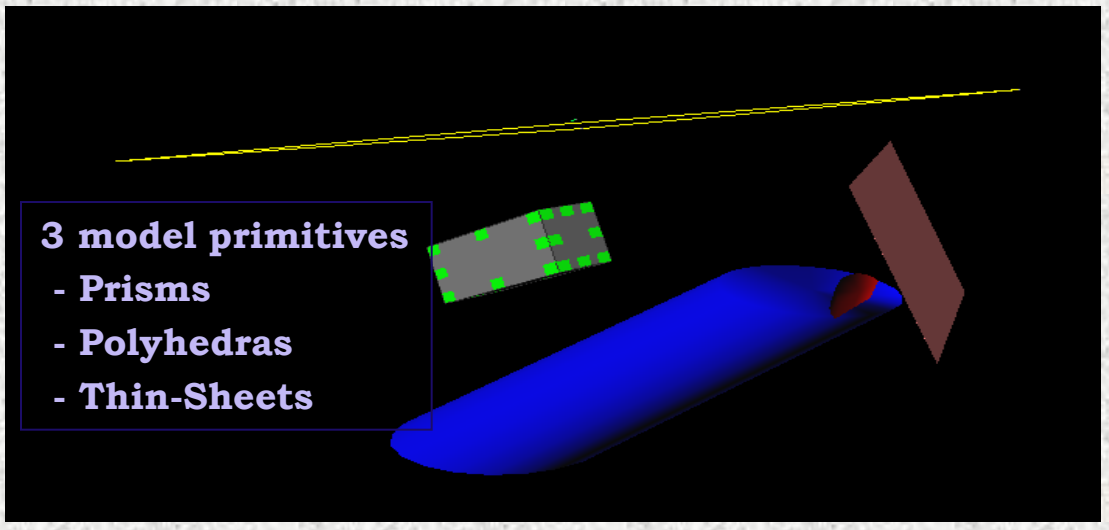
A fully integrated 3D visualization tool

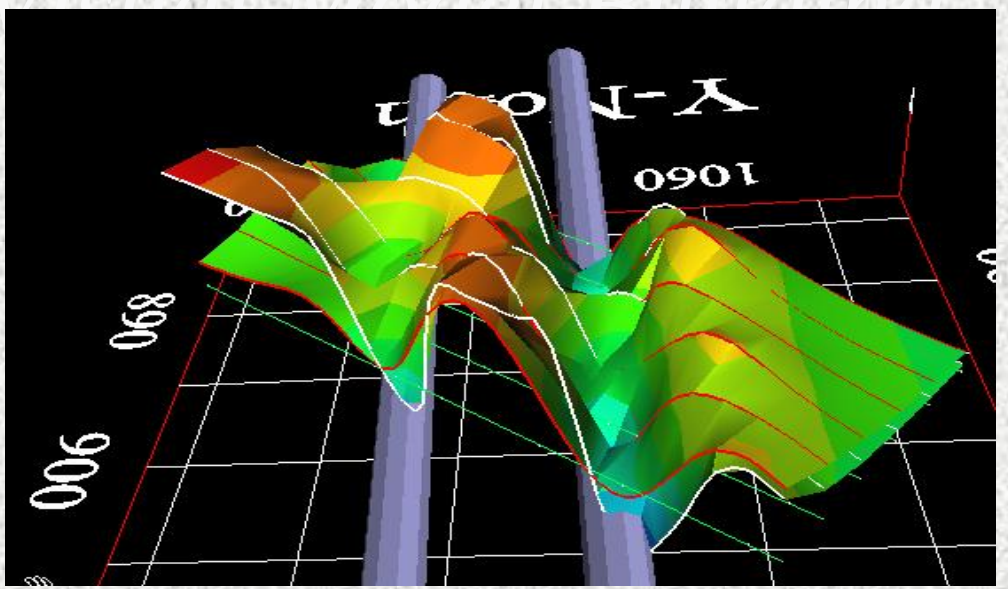
♦Geological CAD Models

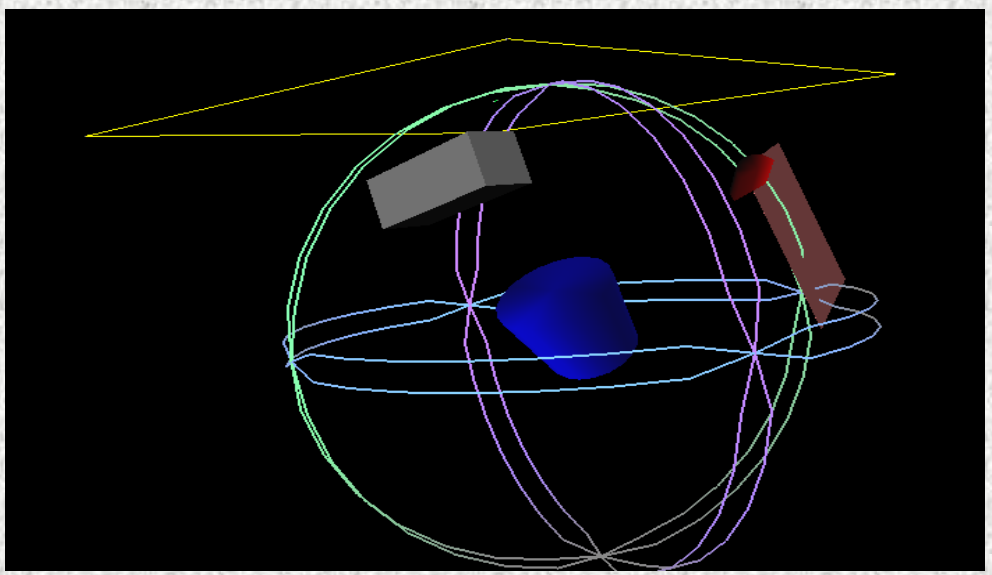


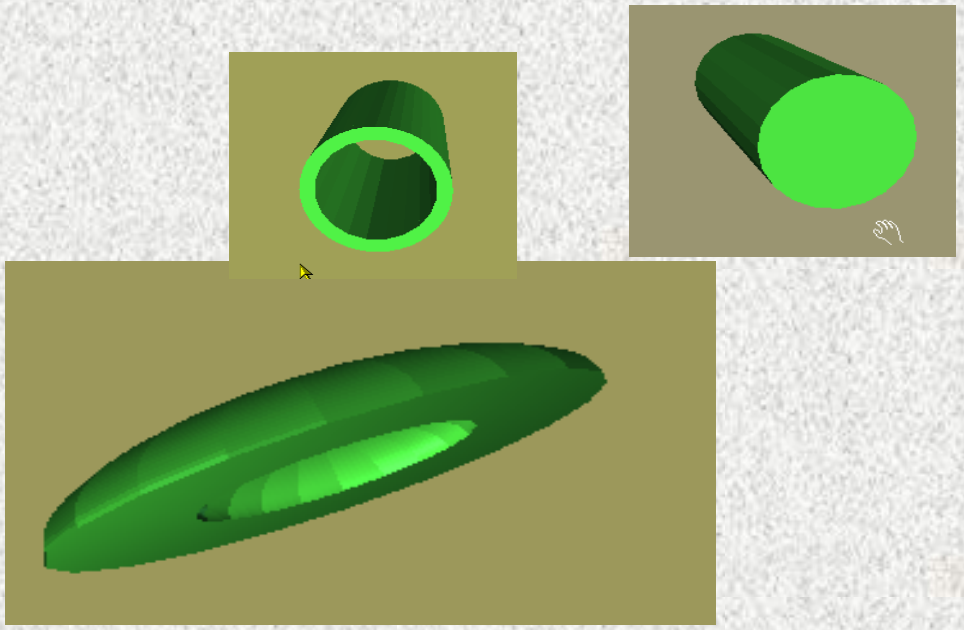
Complex 3D modelling capabilities including imports of geological models from CAD applications

♦ Engineering Applications

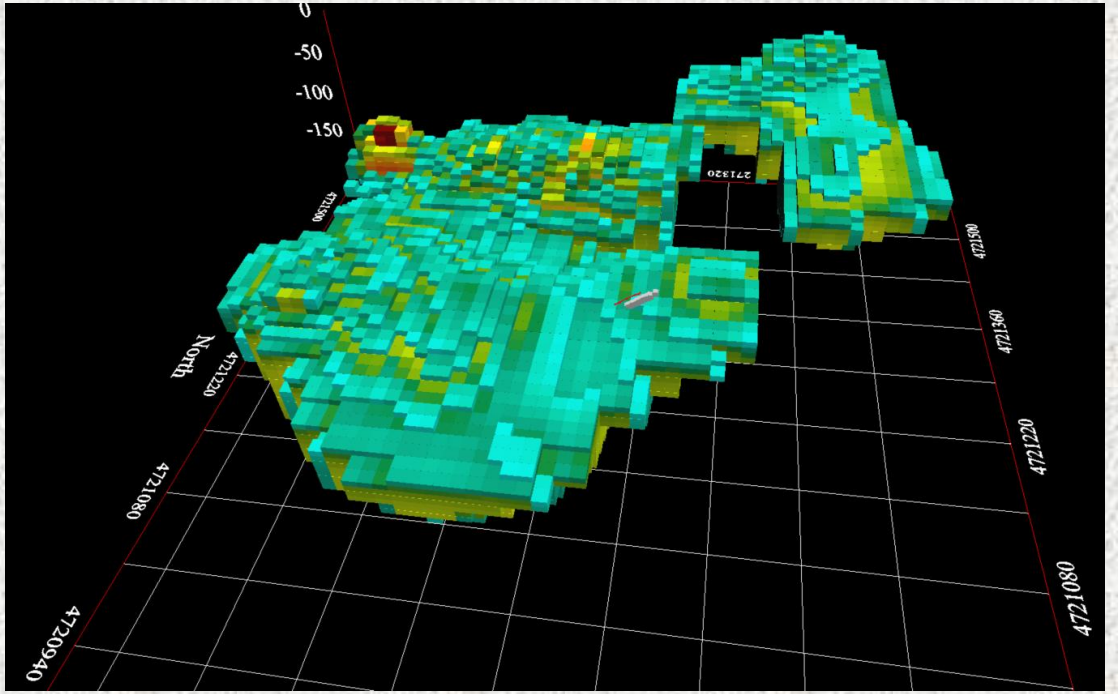




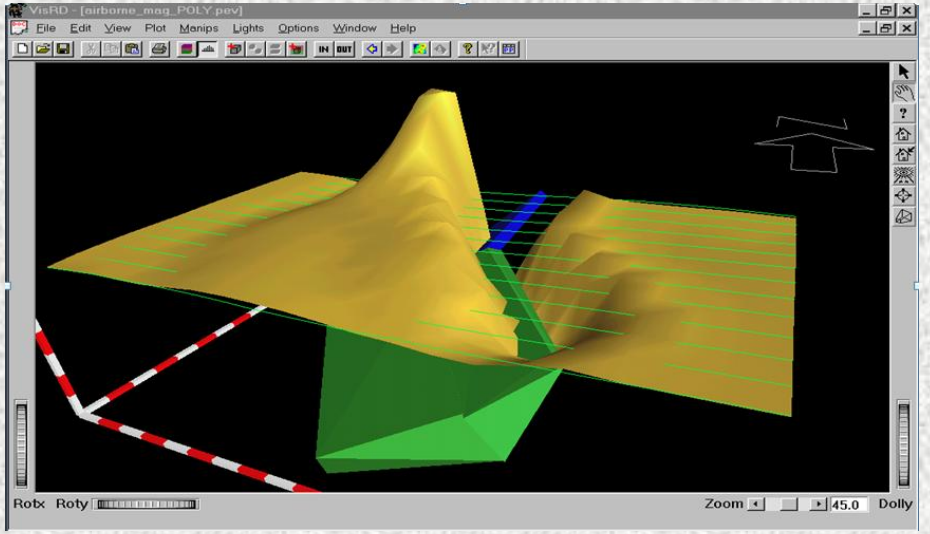




Complex Geological Structure Models



Magnetic Model with boreholes

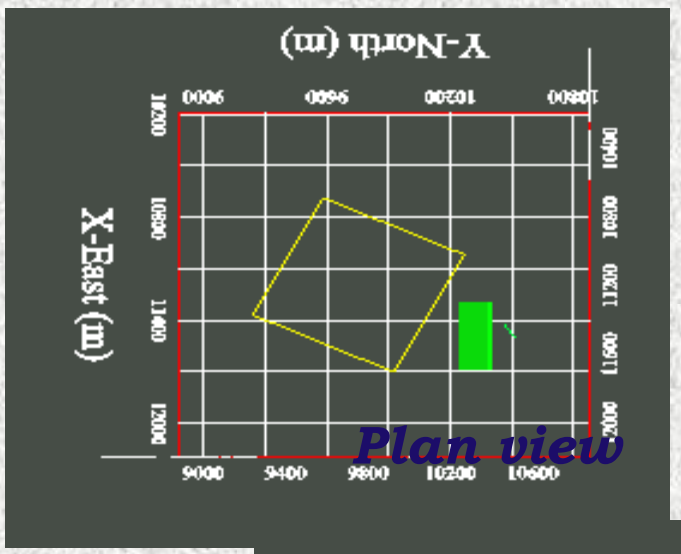


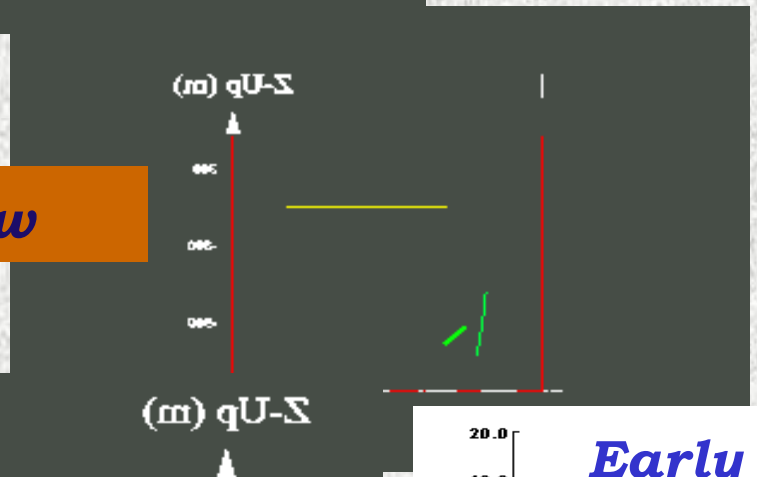
Airborne Magnetic Field Modelling

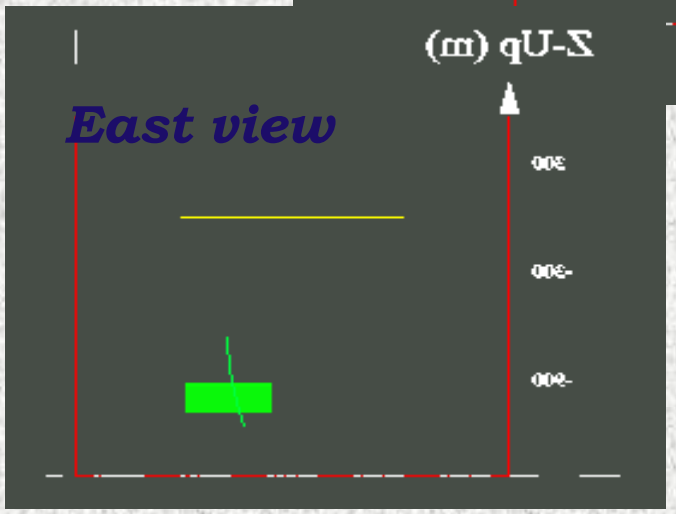
Simulation Calibrations

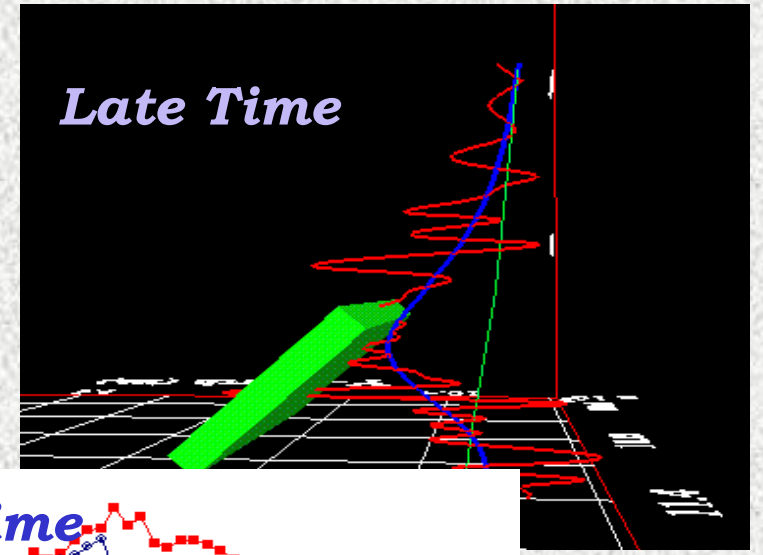
- to other algorithms
- to scale models
- to known geological targets

e.g TEM borehole response

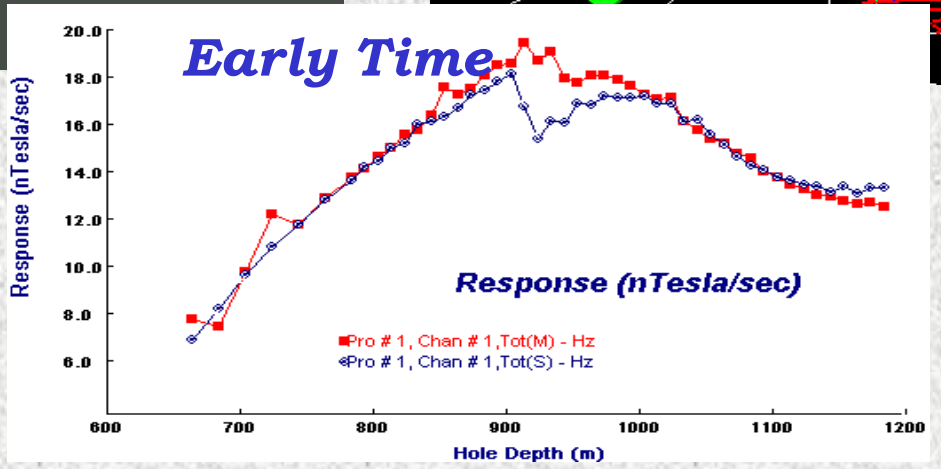


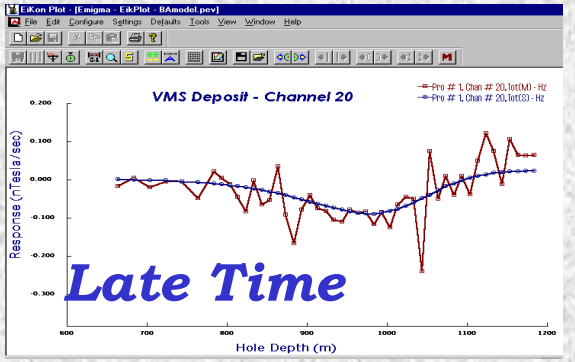




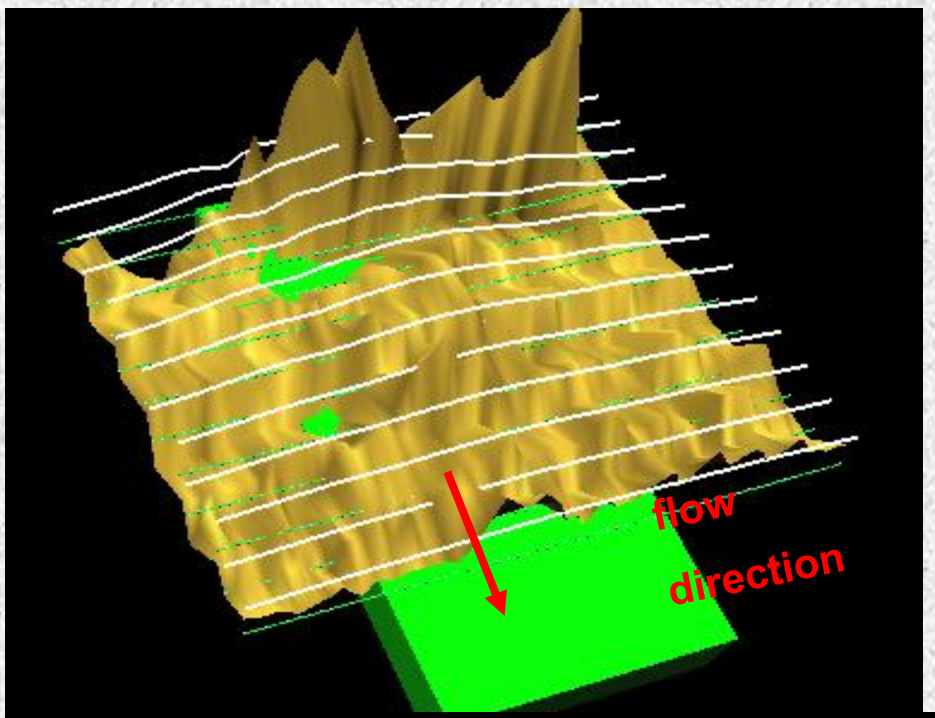


Red line - field data



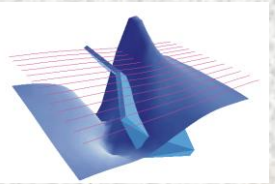


Model and Data Comparison

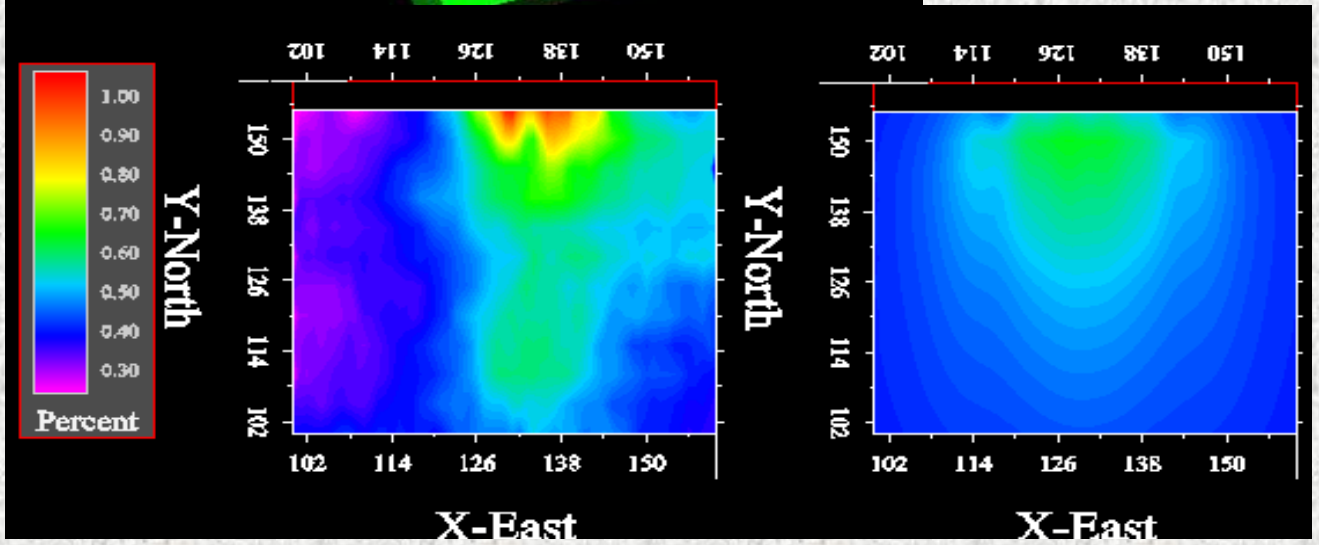


Contaminant Plume - EM31

Canadian landfill site

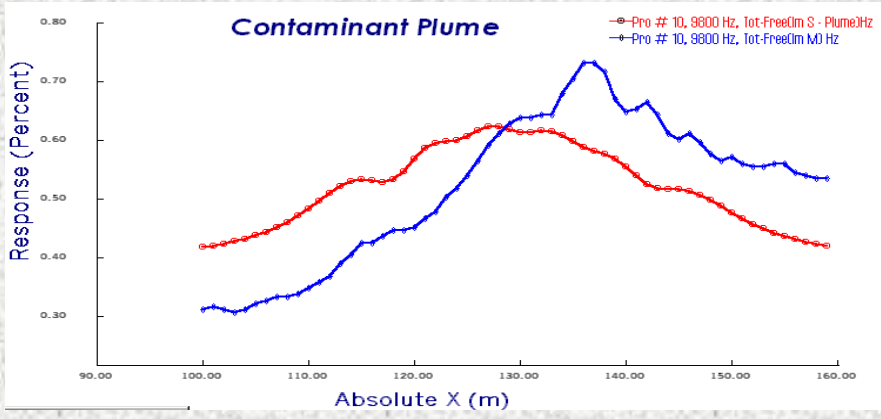


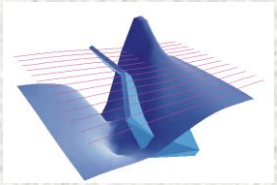
- 3D surfaces
- 2D contours
- 1D plots



Measured Plume Quadrature response

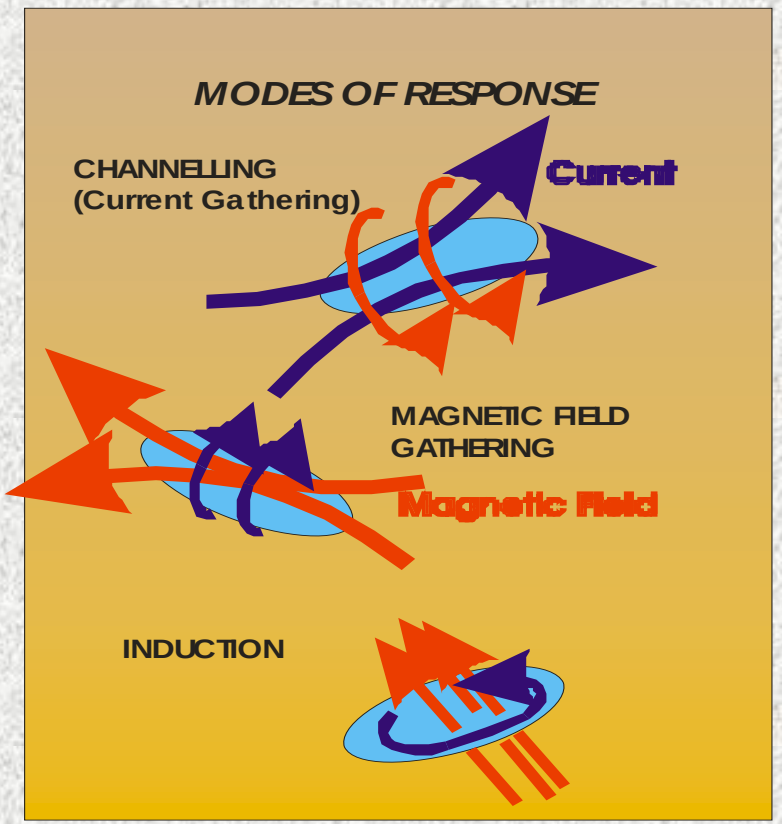
Simulated Plume Quadrature response





EM Geophysical Responses

- **EMIGMA Algorithms**
- LN (for FEM, TEM, IP, MT)
- EiKPlate1 (FEM,TEM,IP,MT) with interaction with host
- Eikplate2 (FEM,TEM) induction with superimposed layered models
- ILN (FEM,TEM)
- MLN Magnetostatic and Current channelling effects
- 3D Resistivity (fast, flexible, accurate)
- MMR ground and borehole



SPHERE, *New for 2025*

- ***Now for Loop, Bipole and Dipole sources***
- ***Fixed and Moving Surveys***
- ***extremely accurate EM and IP responses [spherical harmonic solutions with 200 harmonics - Debye]***
- ***all effects of conductivity, permeability and permeability variations***
- ***complete magnetic effects on inductive and current chanelling responses***
- ***extremely high conductivity and permeability capabilities with frequency ranges from 10^{-5} Hz to 5MHz***

3D Modelling Capabilities 2

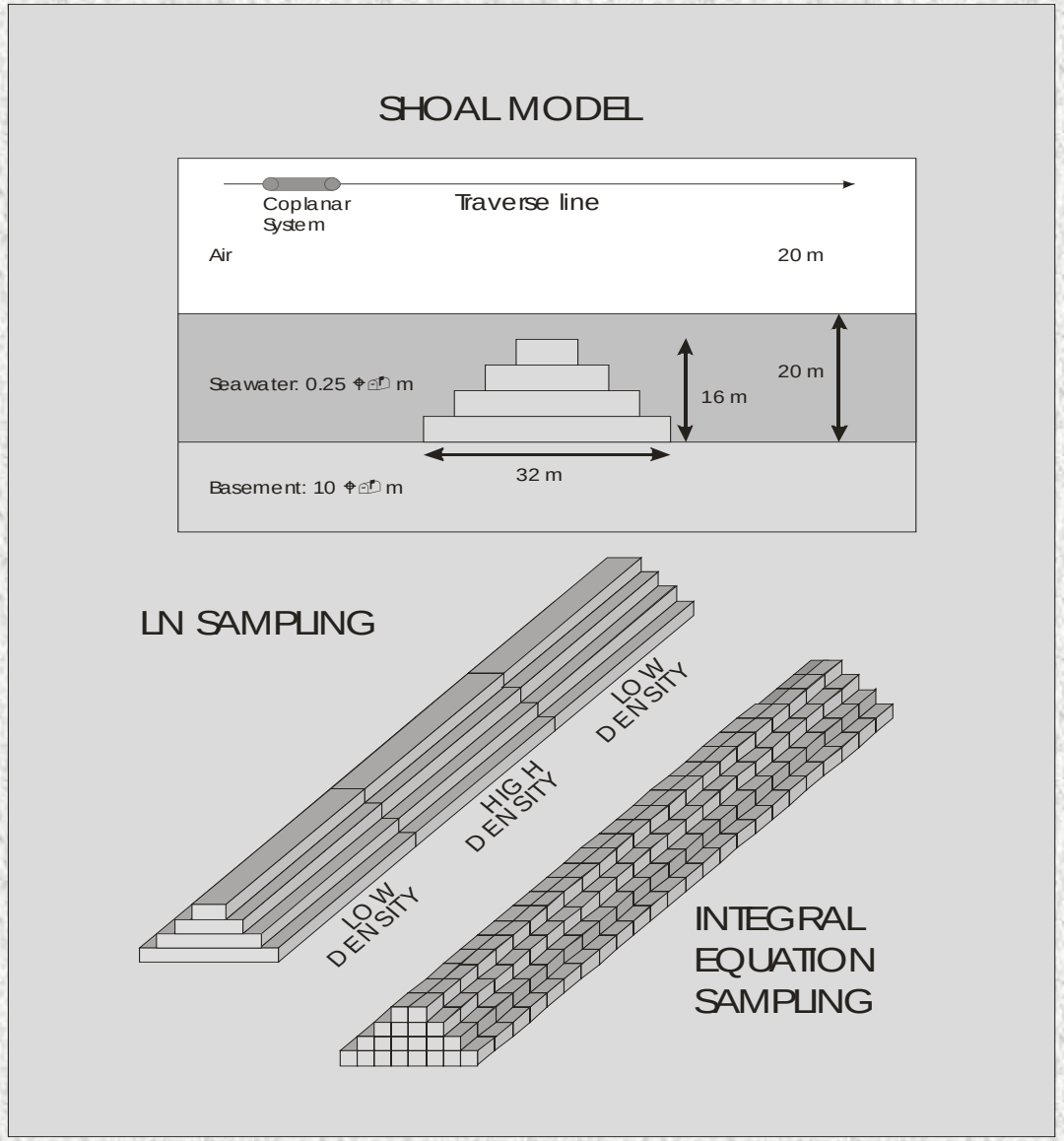
EMIGMA EM Algorithms

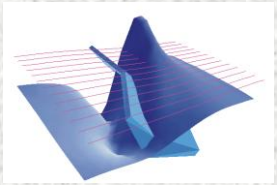
- ✓ LN (prism and polys)
- ✓ EiKPlate (2 thin sheet apps)
- ✓ ILN
- ✓ MLN (prism and polys)
- ✓ Sphere

IE Rapid Convergence

Flexible and

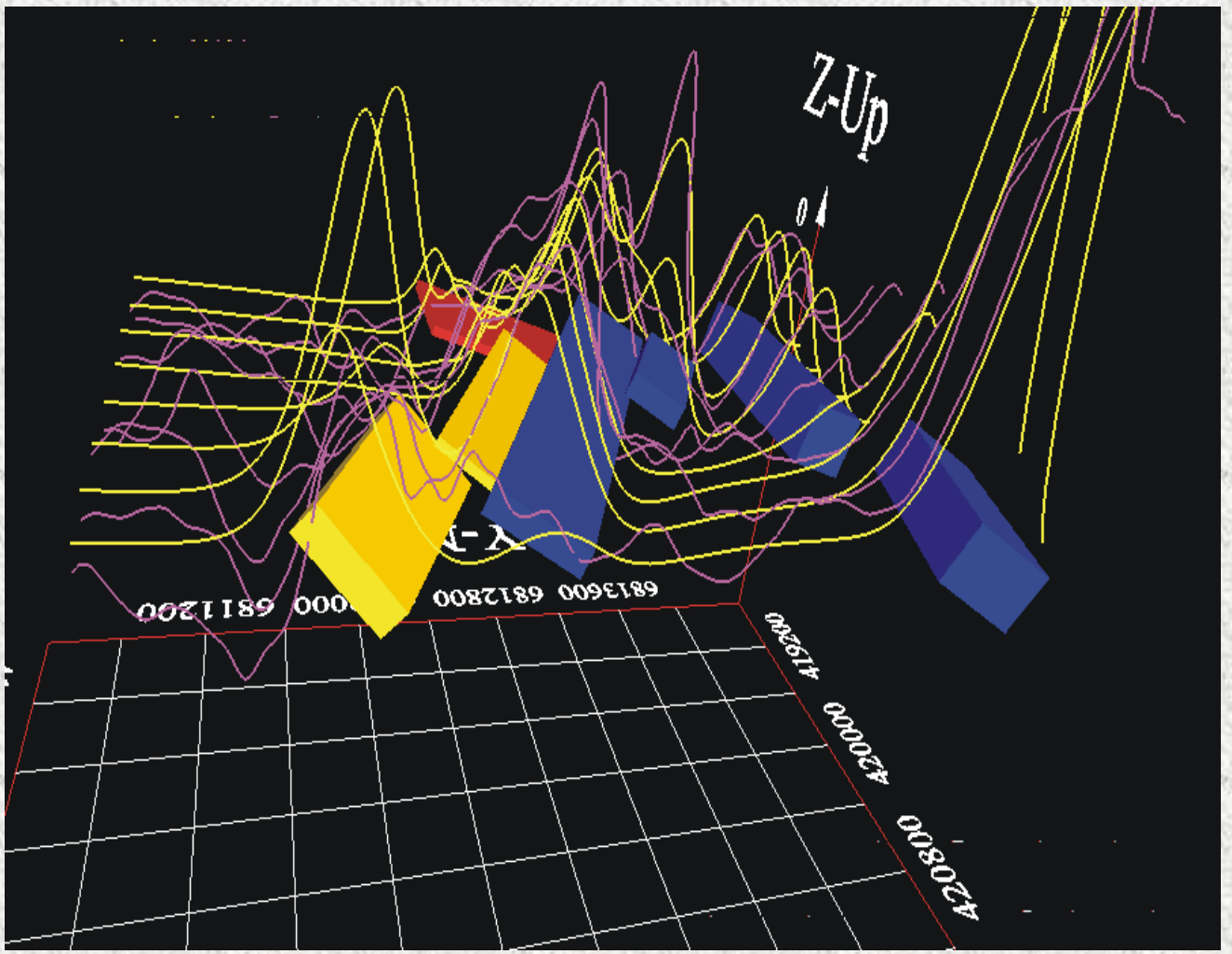
Easy-to-Use Grids





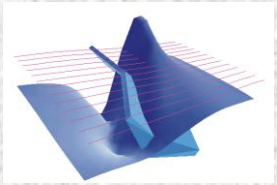
3D Modelling Capabilities 3

Complex Models



Full Range of
Target Interactions

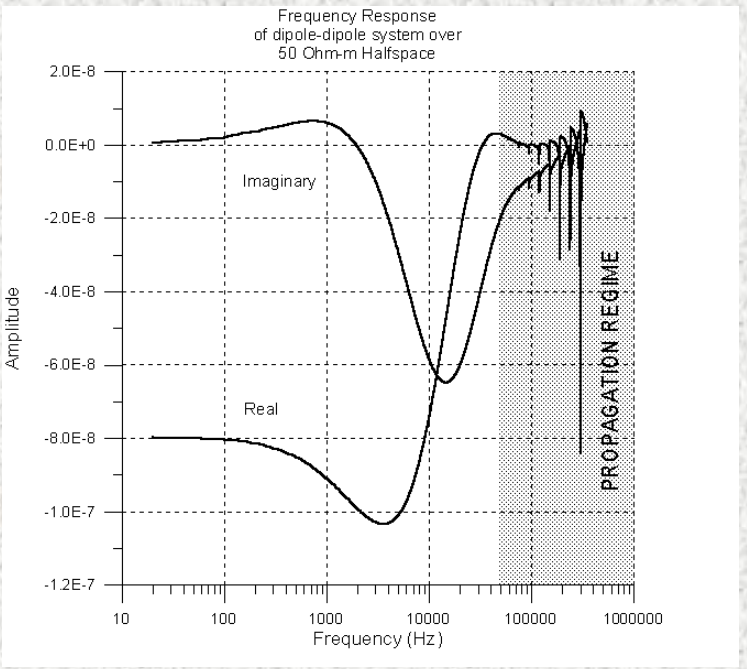
- **Superposition**
- **Near-Field (in contact)**
- **Far-Field (interactions between anomalies at a distance)**



3D Modelling Capabilities 4

~Frequency to Time-Domain Transform

- ♦Why (periodic responses)
- ♦How (frequencyinterpolation)
- ♦ Waveforms (flexible)
- ♦ Bandwidth (controlled)



Typical Magnetic Response

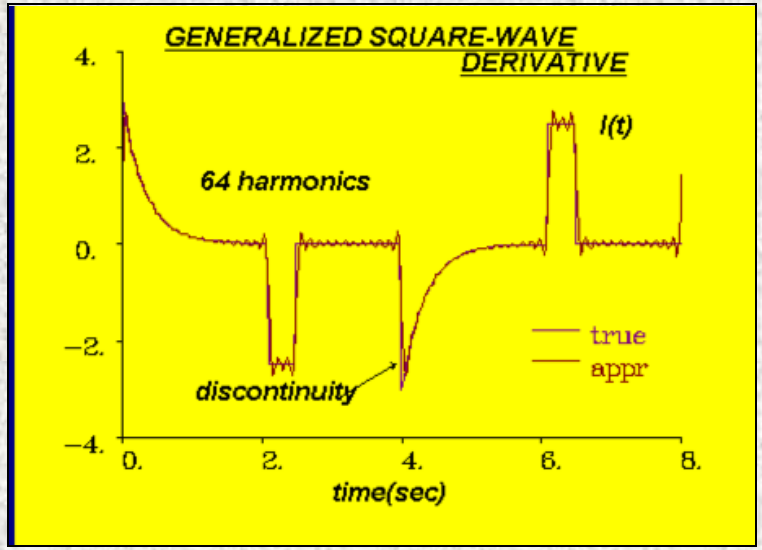
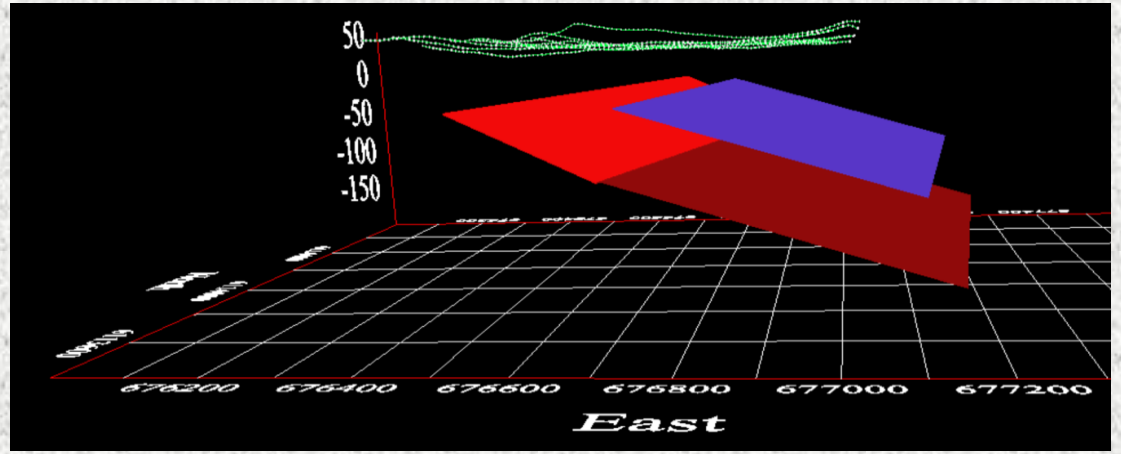


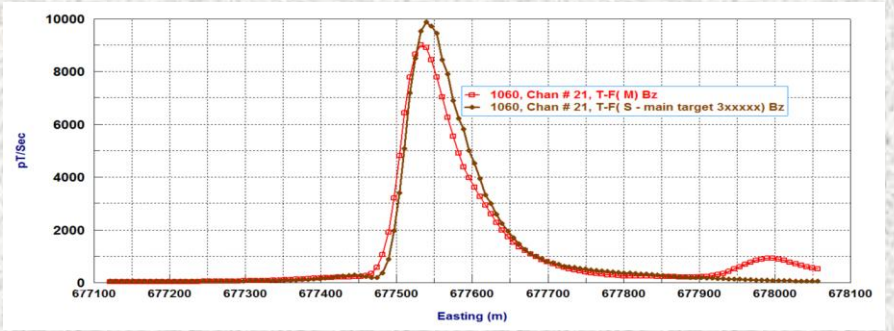
Figure 15: Fourier representation of derivative of the Generalized Square Wave using 64 harmonics.

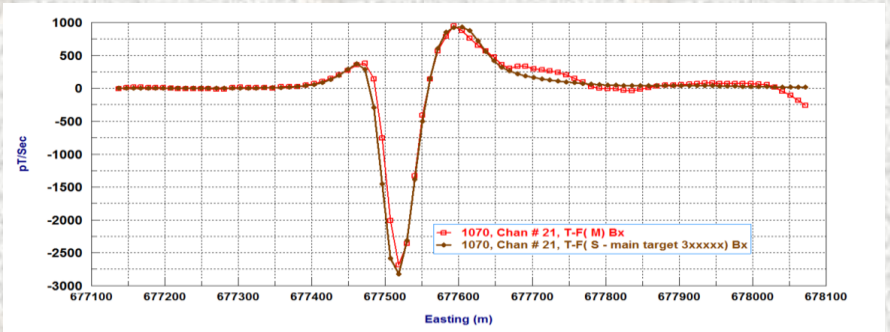
Band limited Coil Response

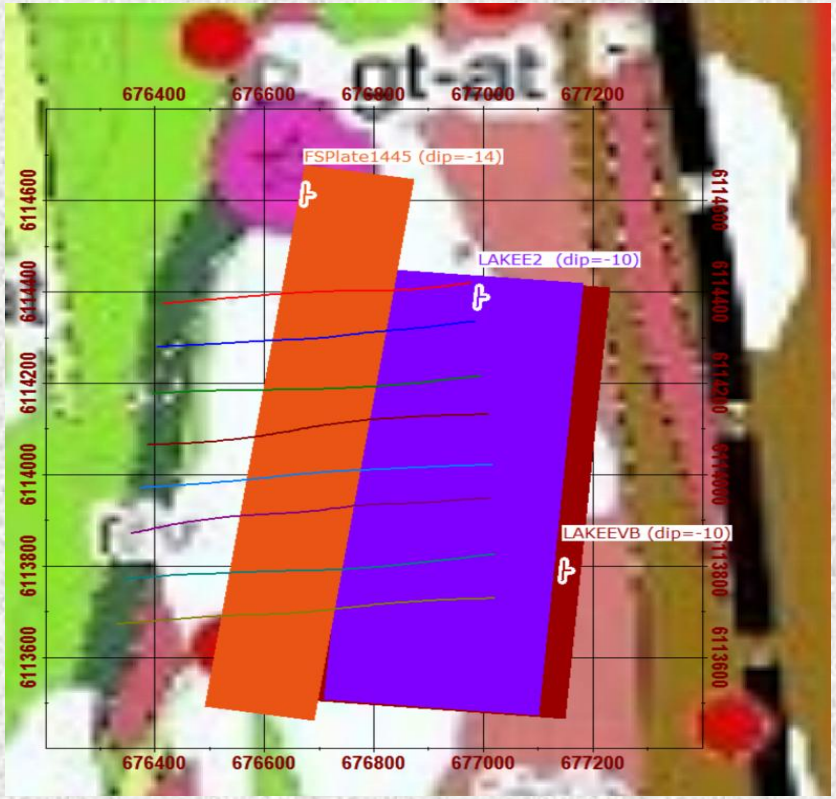
Incredibly accurate transforms

3D Modelling Capabilities
Thin Sheet Inversions





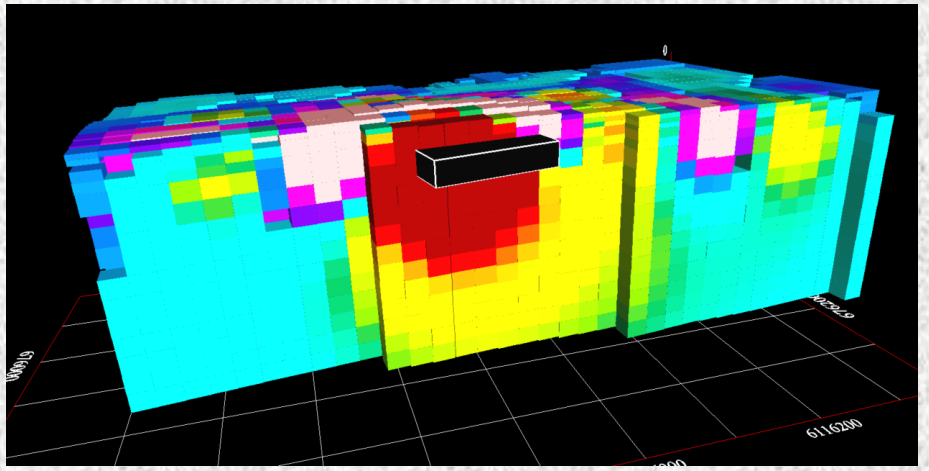


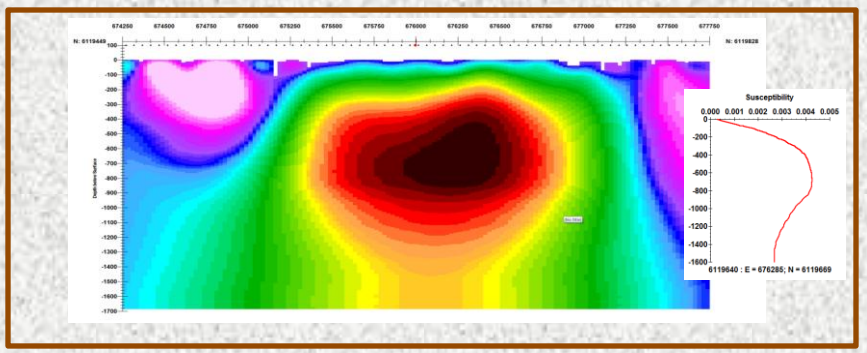


mid-time Inversion Model fits to AEM data

Inversion Capabilities 1

3D Magnetic field Inversion for Susceptibility





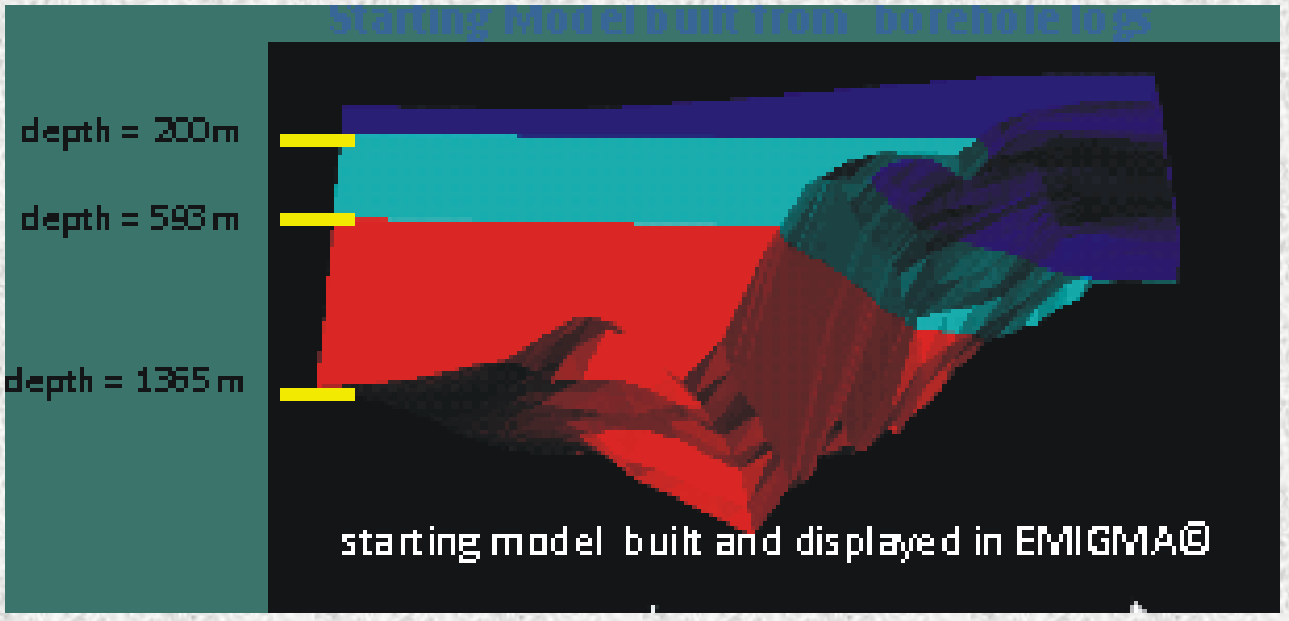
- Multiple survey heights
- Gradients
- Components (i.e. fluxgate data)
- Matrix Inversion
- Optimization
- Linear/ Non-Linear
- 3D Starting Models
- Strike rotated inversion grids

- Magnetization Vector Inversions (e.g. UXO imaging)
- 3D Euler solution with statistical processing

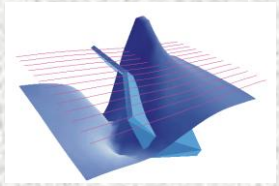
3D Gravity Inversion

Inversion Capabilities 2

- **Utilization of topography**
- **Gradient capabilities**
- **use of horizon and drill hole constraints**
- **Fast inversions through new compile and multi-core processing**



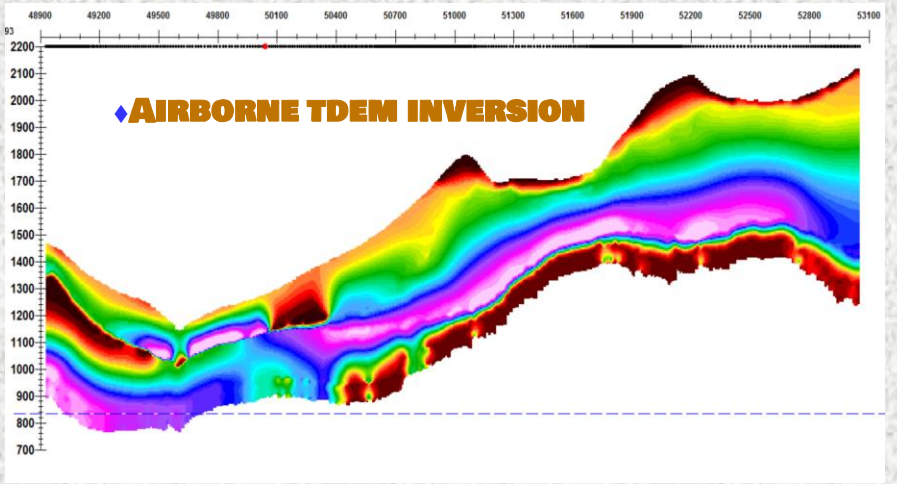
➢ **3D Extended Euler solutions plus statistical processing**

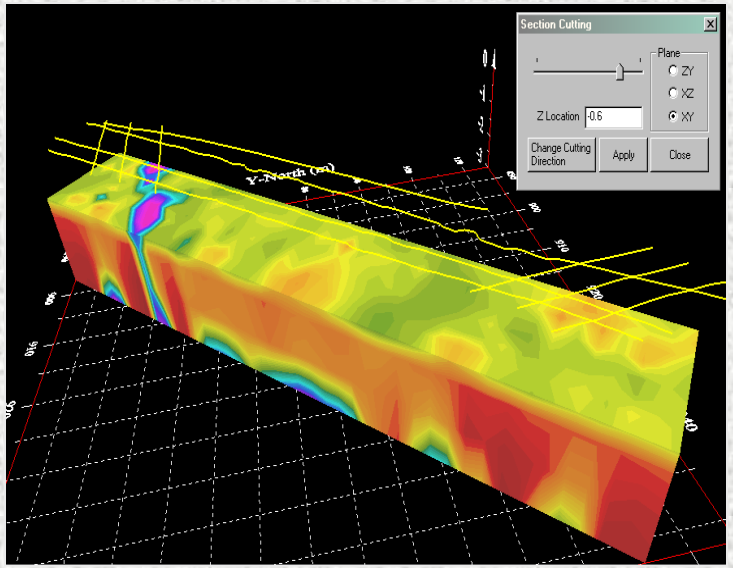


Inversion Capabilities 3

1D Inversion

TEM, FEM, Resistivity, CSEM, CSAMT





TEM : multiple base frequency and
multiple component capabilities
- in-loop, out-of-loop, ground, airborne

FEM : multi-frequency, multi-separation,
- ground , HEM, fixed-wing

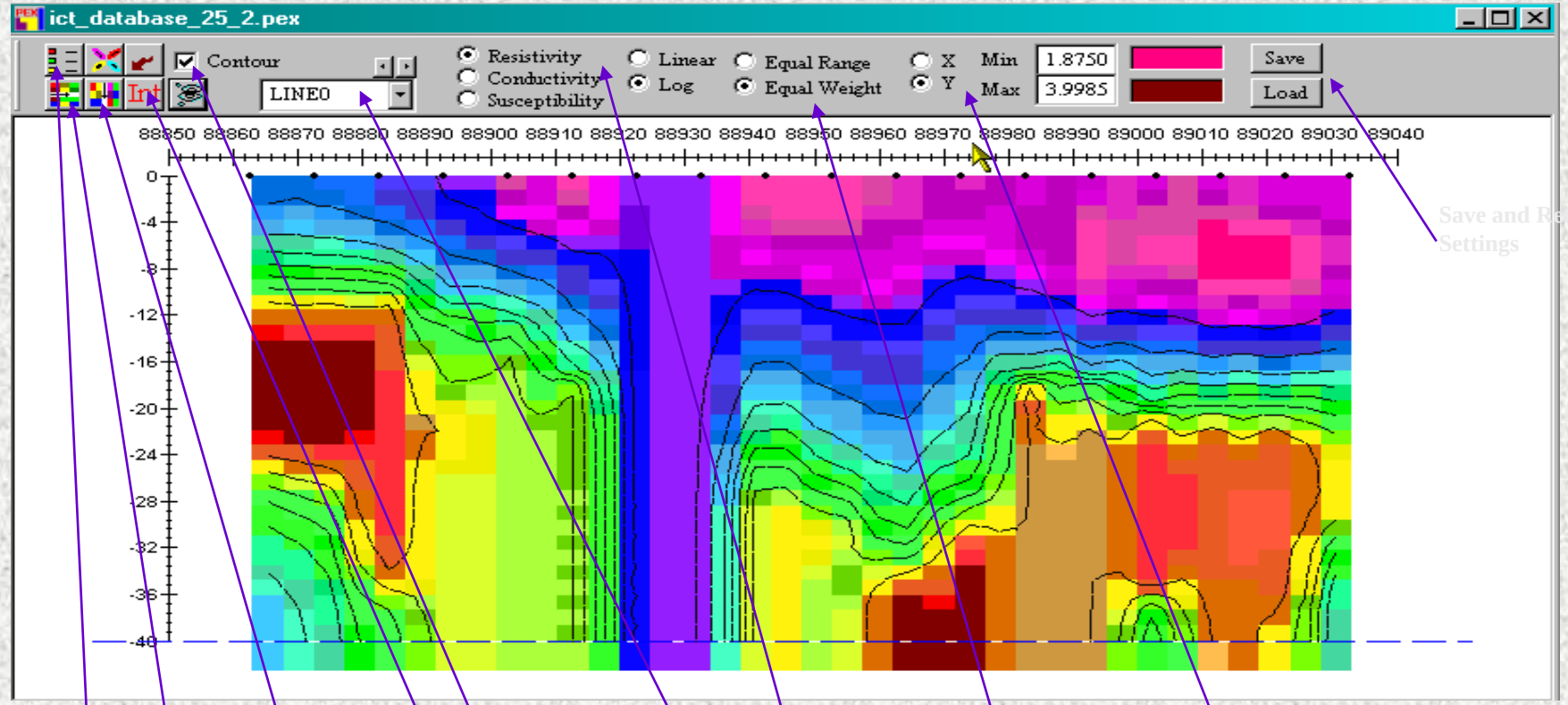
Resistivity: 1D Inversion

CSEM : electric and/or magnetic field inversions
CSAMT : impedance inversions
– apparent resistivity and phase

MT, VLFR – impedance/phase

Inversion Capabilities 4

PEX- file Viewer



Legend

Interpolate Vertically

Interpolate Horizotally

2D Interpolation

Apply Contour

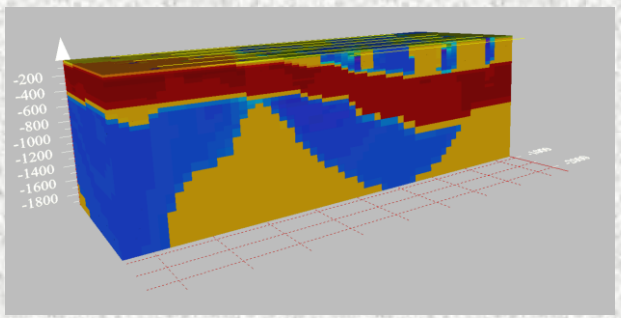
Select Line

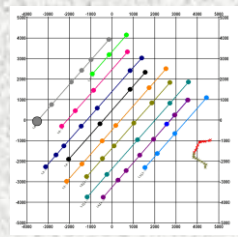
ModelUnits

Colour Distribution
Equal Range – intervals equal
Equal Weight – distribution equal

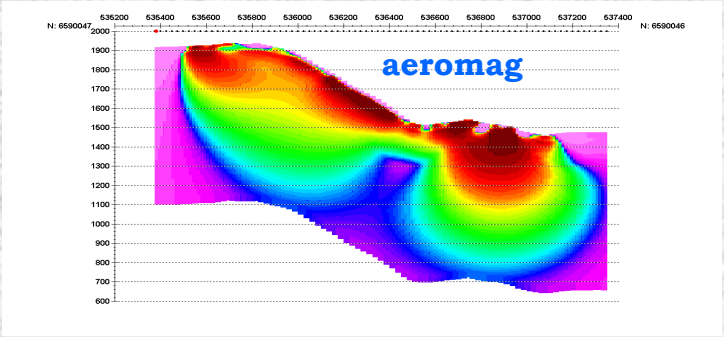
Horizontal Axis selection

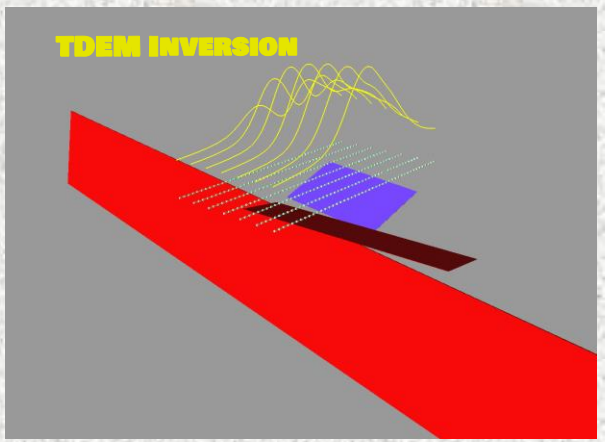
Inversion Capabilities 5





CSEM





3D Inversion

Gravity and Magnetics

Resistivity

CSEM – land based

CSAMT/MT

TDEM/FDEM – thin sheet inversion

Gravity and Magnetics
ground or airborne data with measured and processed derivatives
topography effects, geological structures and a host of other features

Resistivity – dipole-dipole, pole-dipole, gradient and pole-pole surveys
-resistivity constraints and user-specified starting model
-- strong constrat non-born techniques

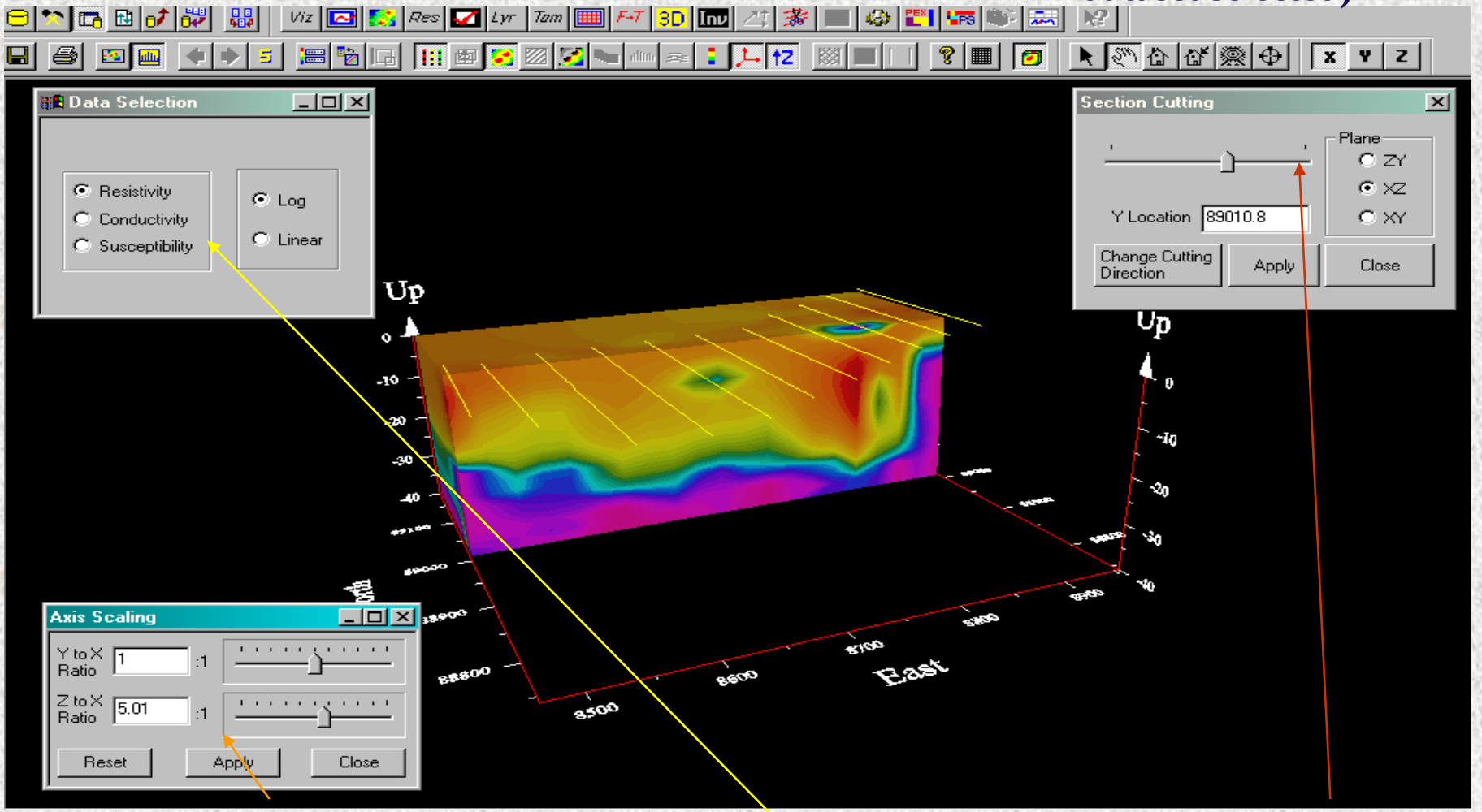
CSEM/CSAMT
-3D inversion
-accurate 3D inversion (utilizing source geometry)

TDEM/FDEM – multi-plate inversions, multi-components, constrained inversions

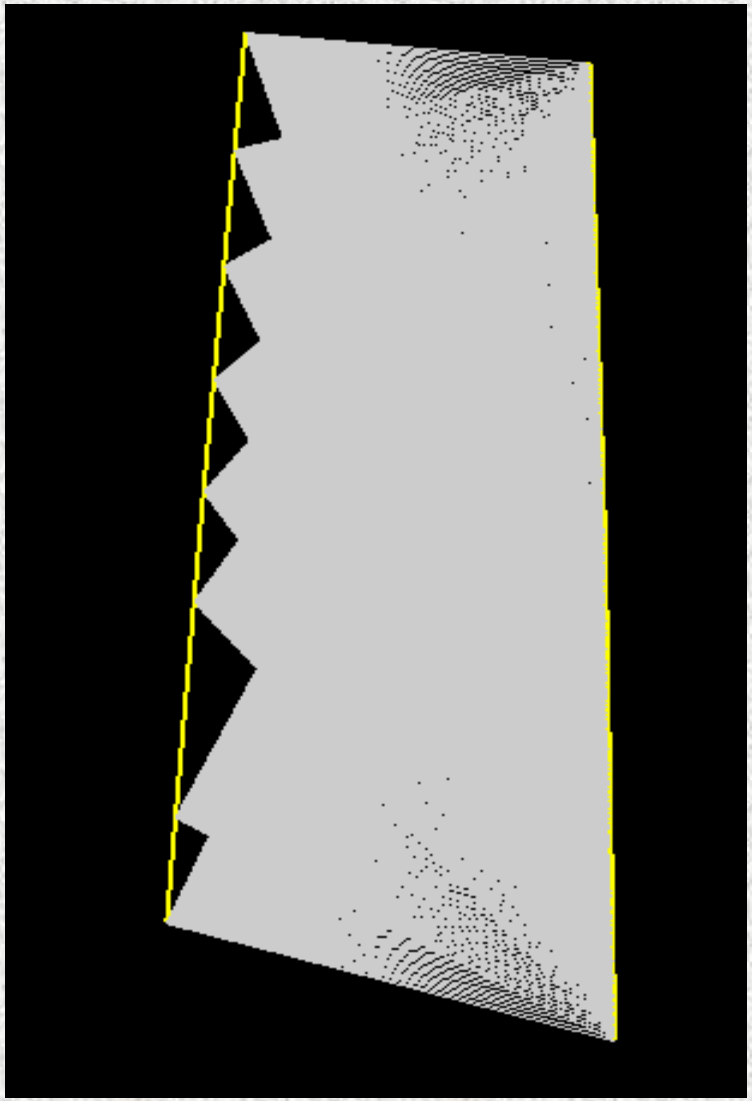
EIKON TECHNOLOGIES

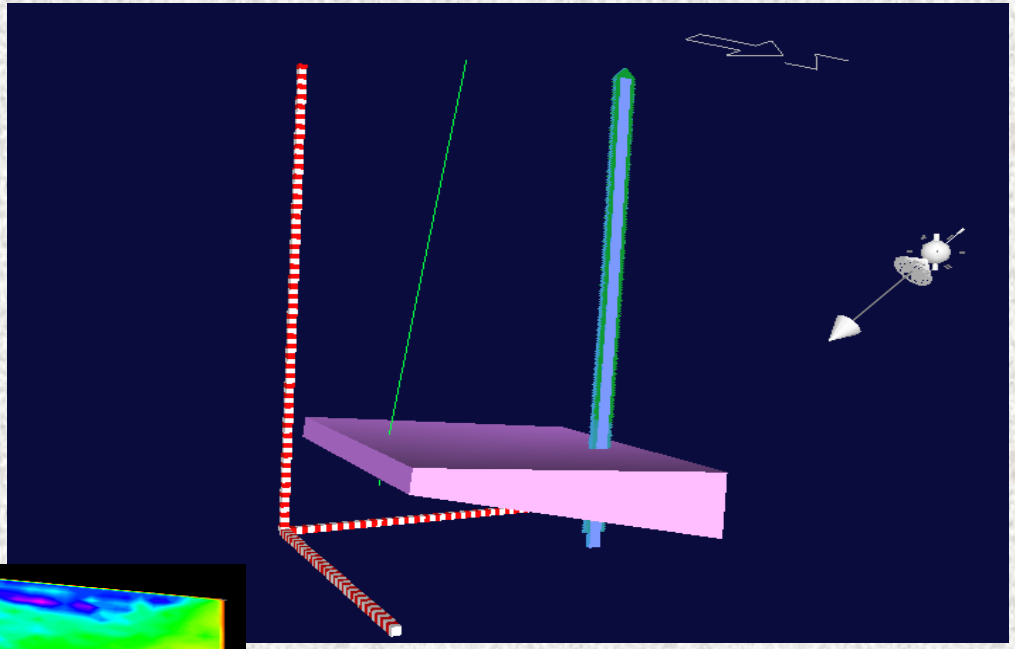
Inversion Capabilities 5

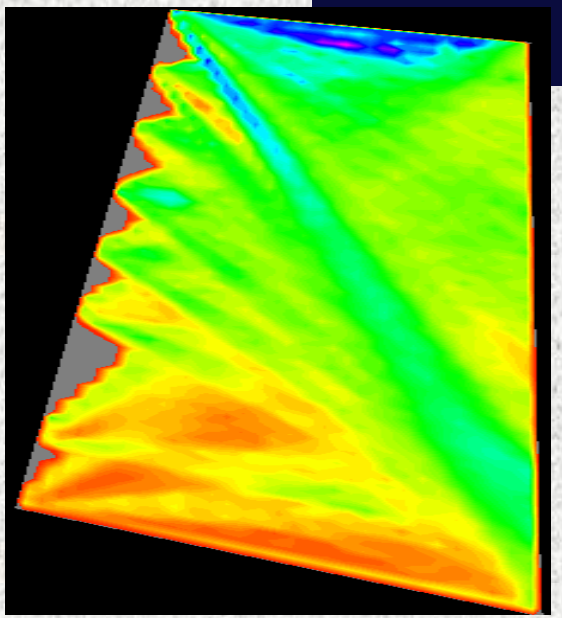
3D Volume Contour (with Inversion model dataset selected)



Crosshole Applications

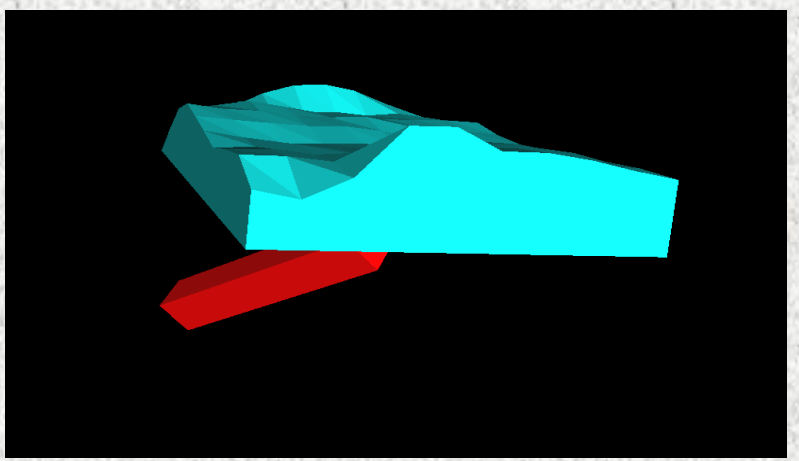






RIM data – lead mine

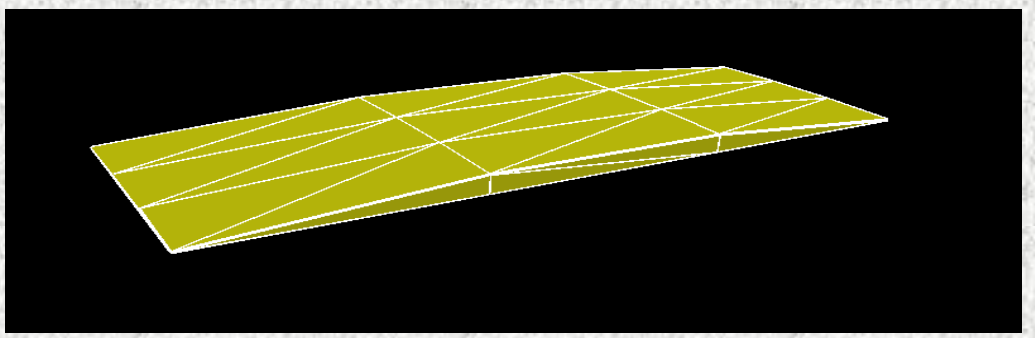
EIKON TECHNOLOGIES



CAD Model Building Tools

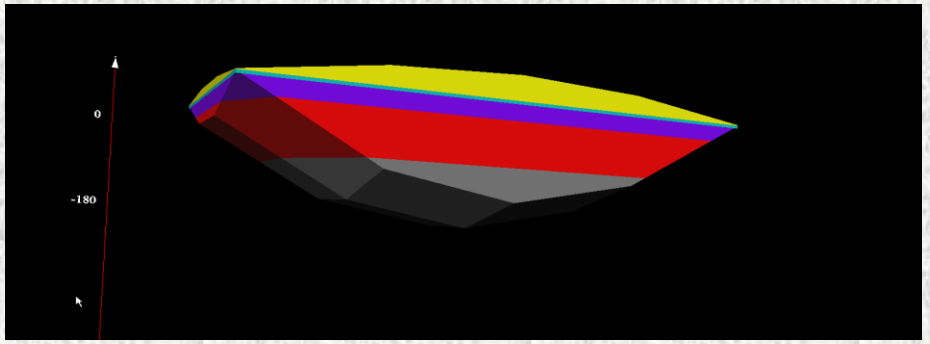
Topography plus Anomaly – MT project

Accurate simulation of strong effects on electric field field of topography (not Born approximations)



♦**Anticline – MT plus gravity project**

CAD Model Building Tools

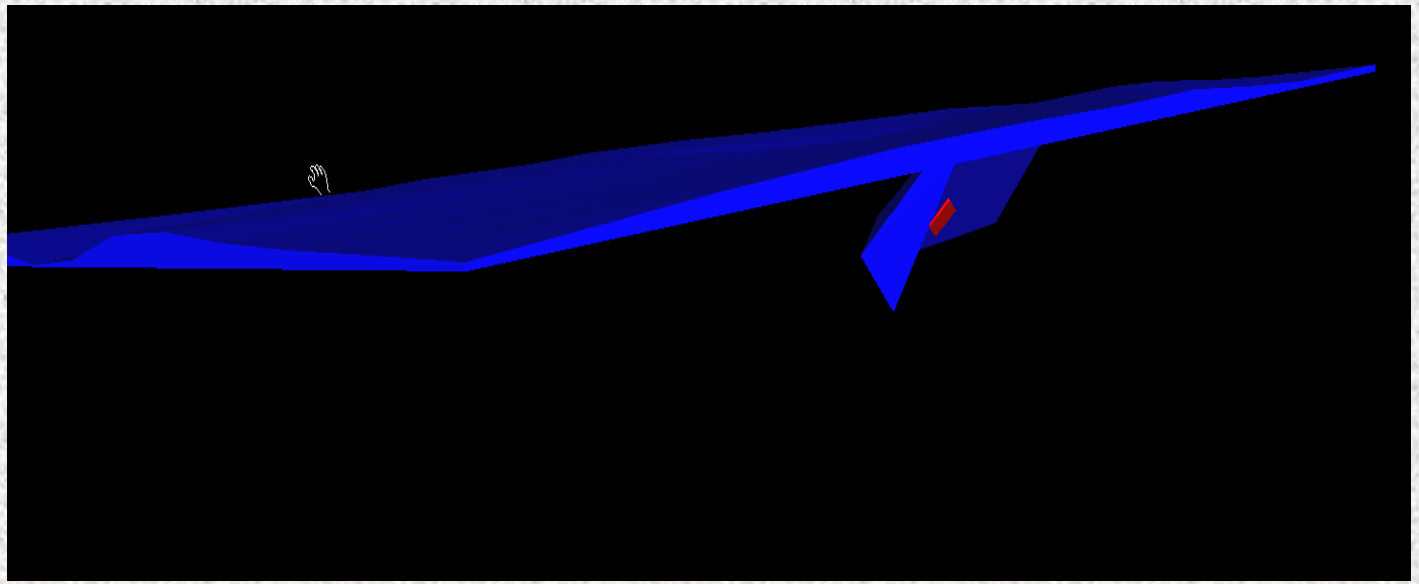


Waste Dump Modeling:

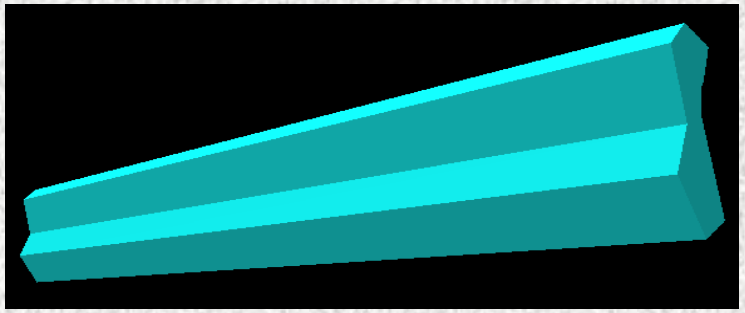
for FDEM, Gravity, IP, and Magnetic surveys

- **Magnetic Intrusions plus Topography plus Target**

for Airborne Magnetics and EM surveys

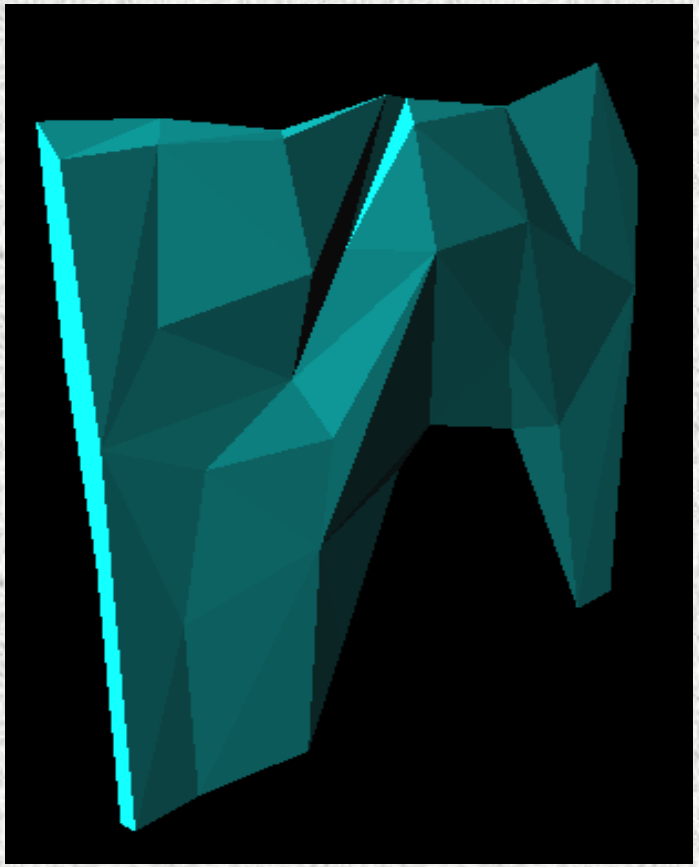


CAD Model Building Tools



♦**Conductor Model for TDEM Simulation:**

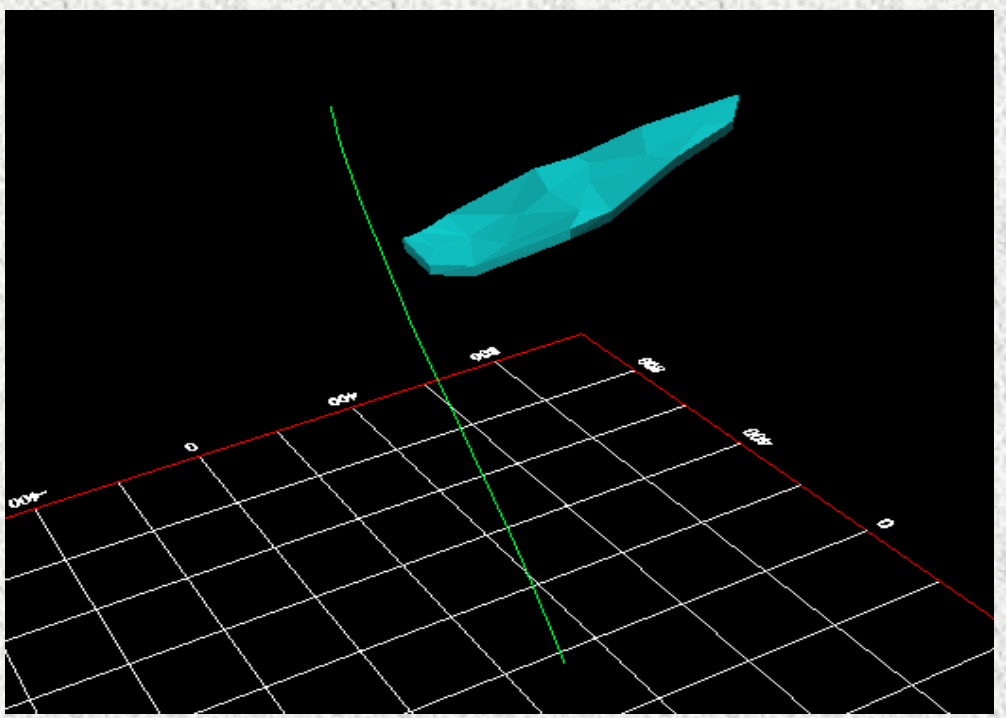
Copper – Nickel project



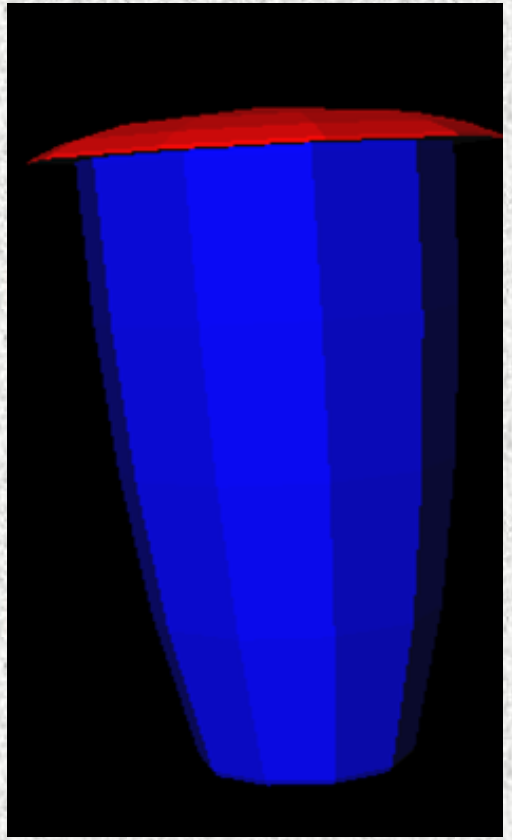
Copper-Nickel Resource:

Simulation of CAD model for Magnetics, Gravity, EM

CAD Model Building Tools



♦**Massive Sulphide Deposit CAD Model for simulation**
– ***Borehole TDEM plus Magnetics***

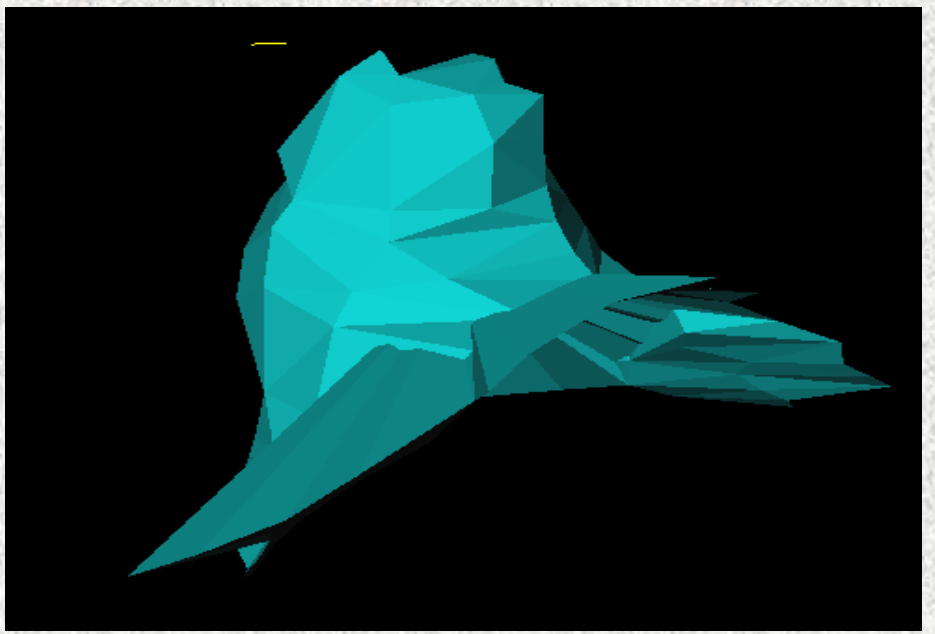


♦**Classic Salt Dome Model - Gravity**

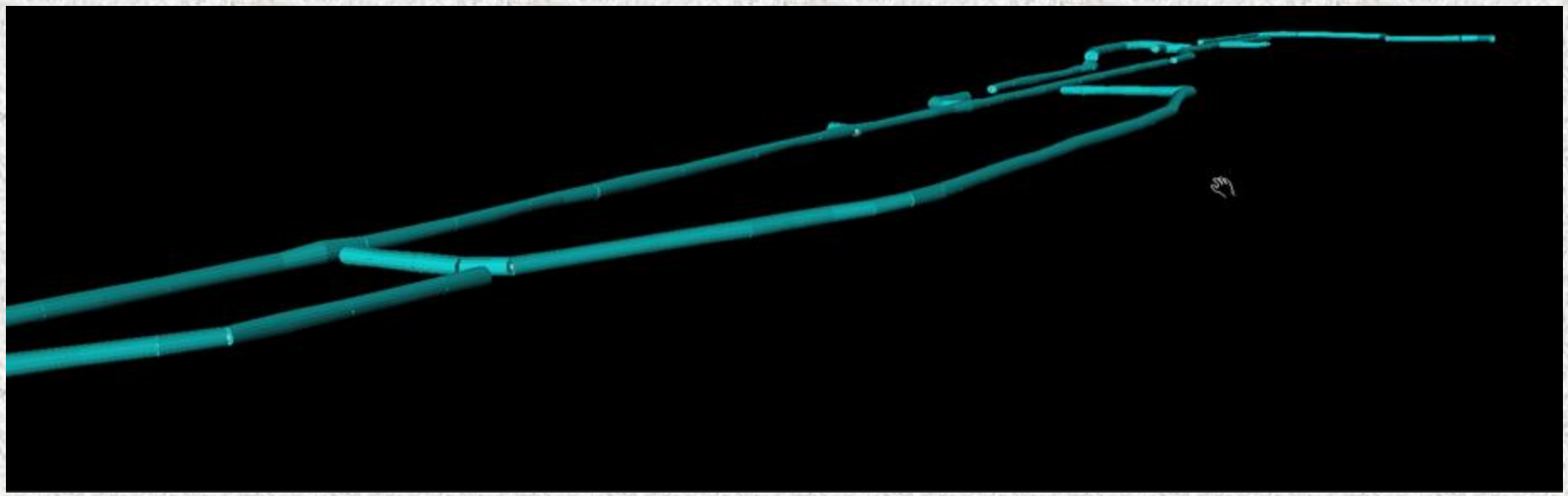
CAD Model Building Tools

- **Steel Utility Pipe Model -**
  for simulation of towed FDEM ground array

- **Gold Resource -**
  IP, Gravity and Magnetics



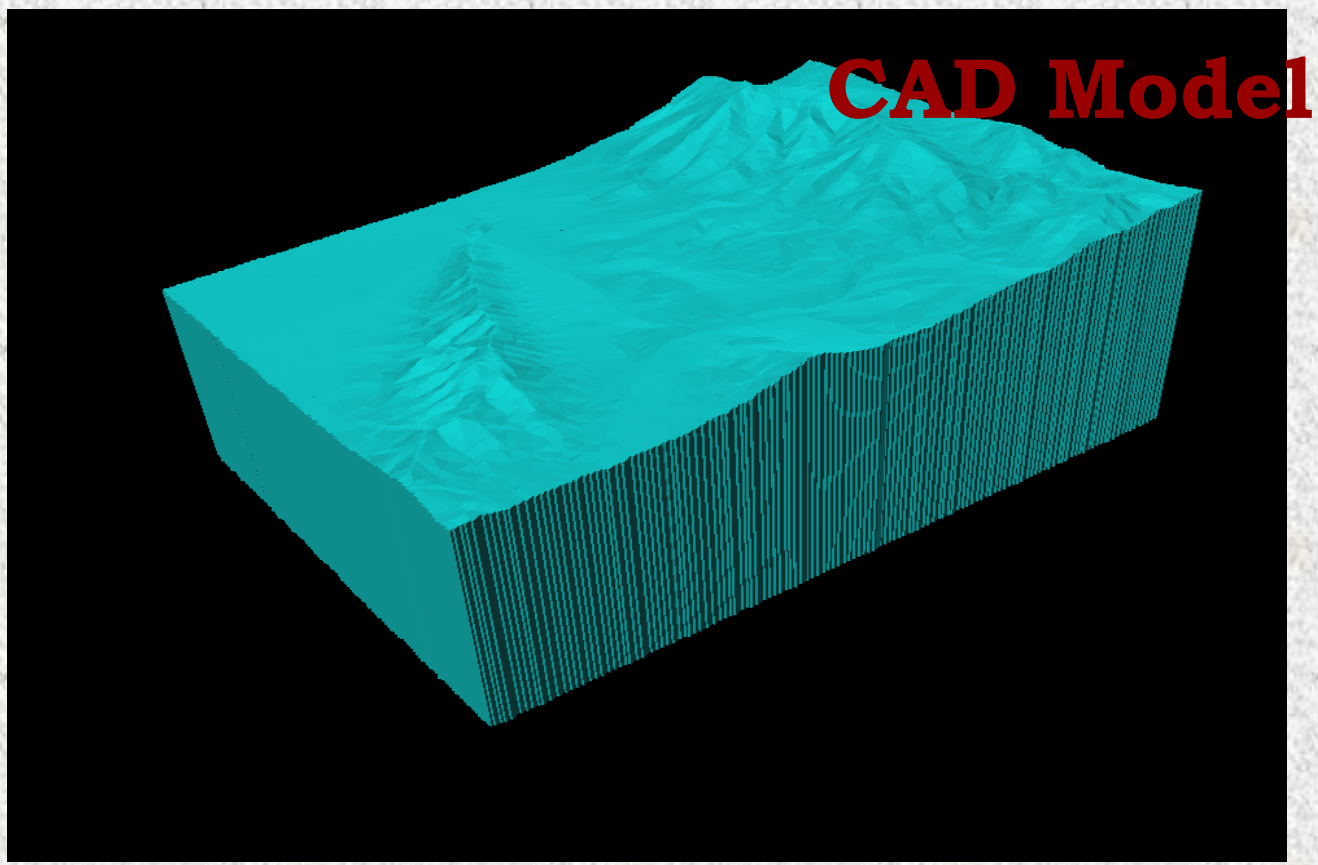
CAD Model Building Tools



- **Underground Mine Workings:**

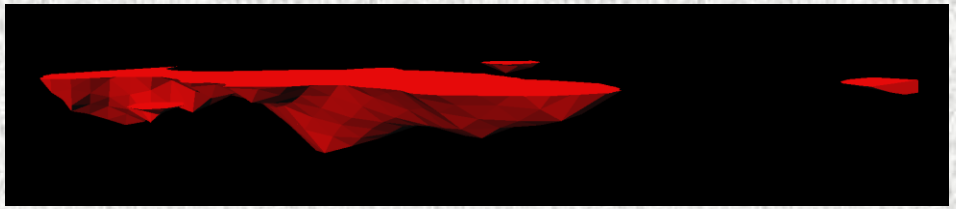
Borehole IP and Ground TDEM studies

CAD Model Building Tools

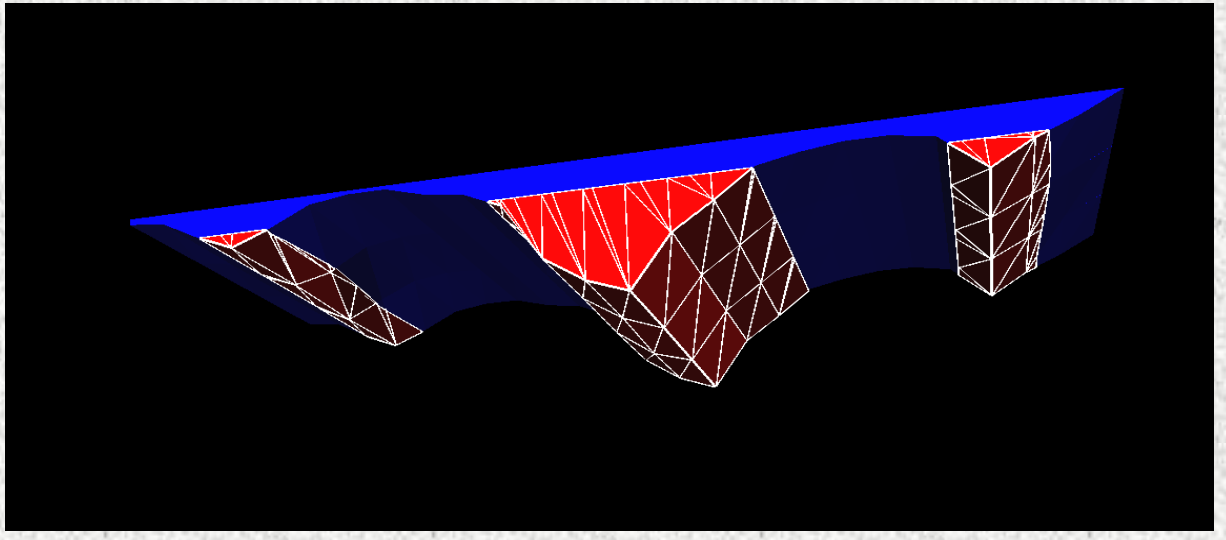


♦Complex Topography Model: Gravity

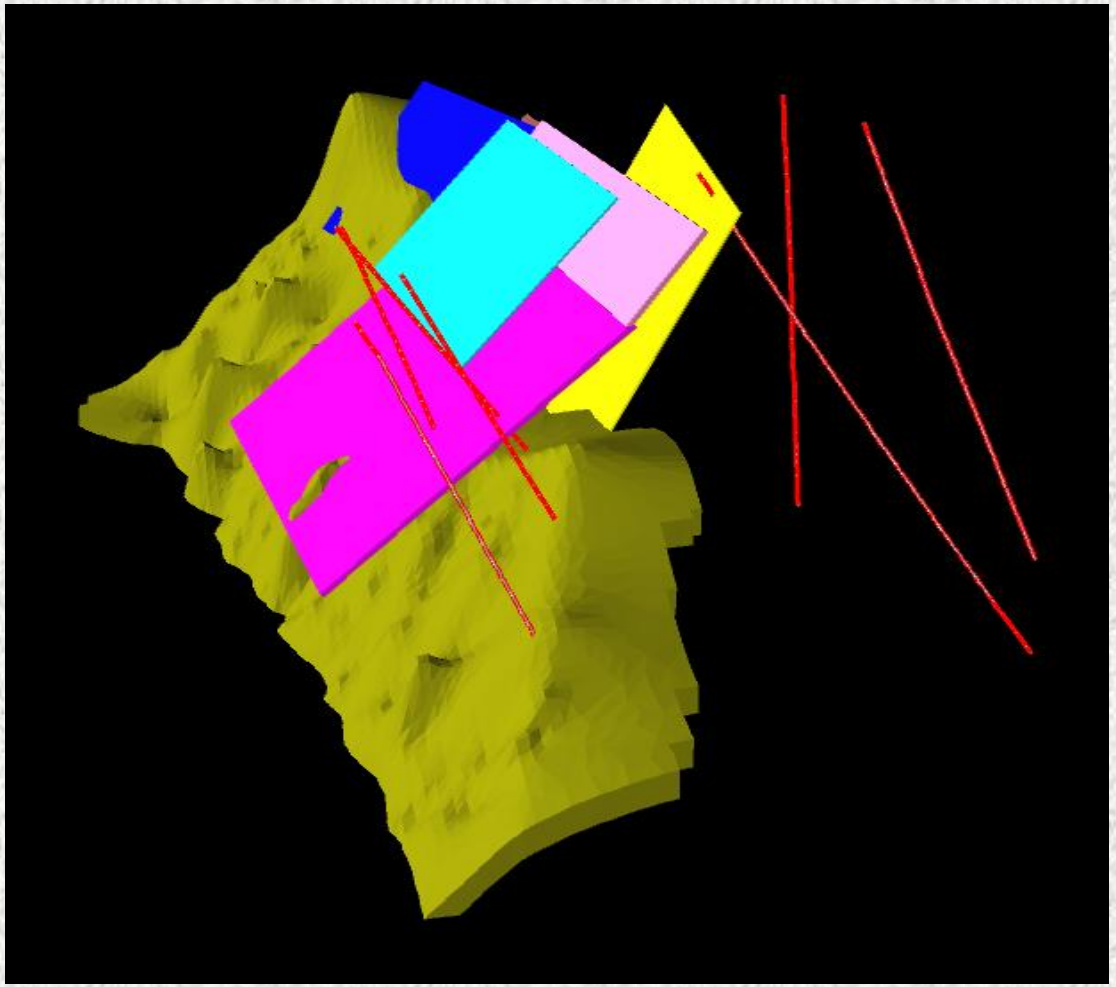
- satellite DEM models can be incorporated to models and inversions when gravity gradients are within the topography . This is especially important for geotechnical work and exploration in mountainous terrain.



- **Basin Model: Gravity**
  - **model derived from drill core results**

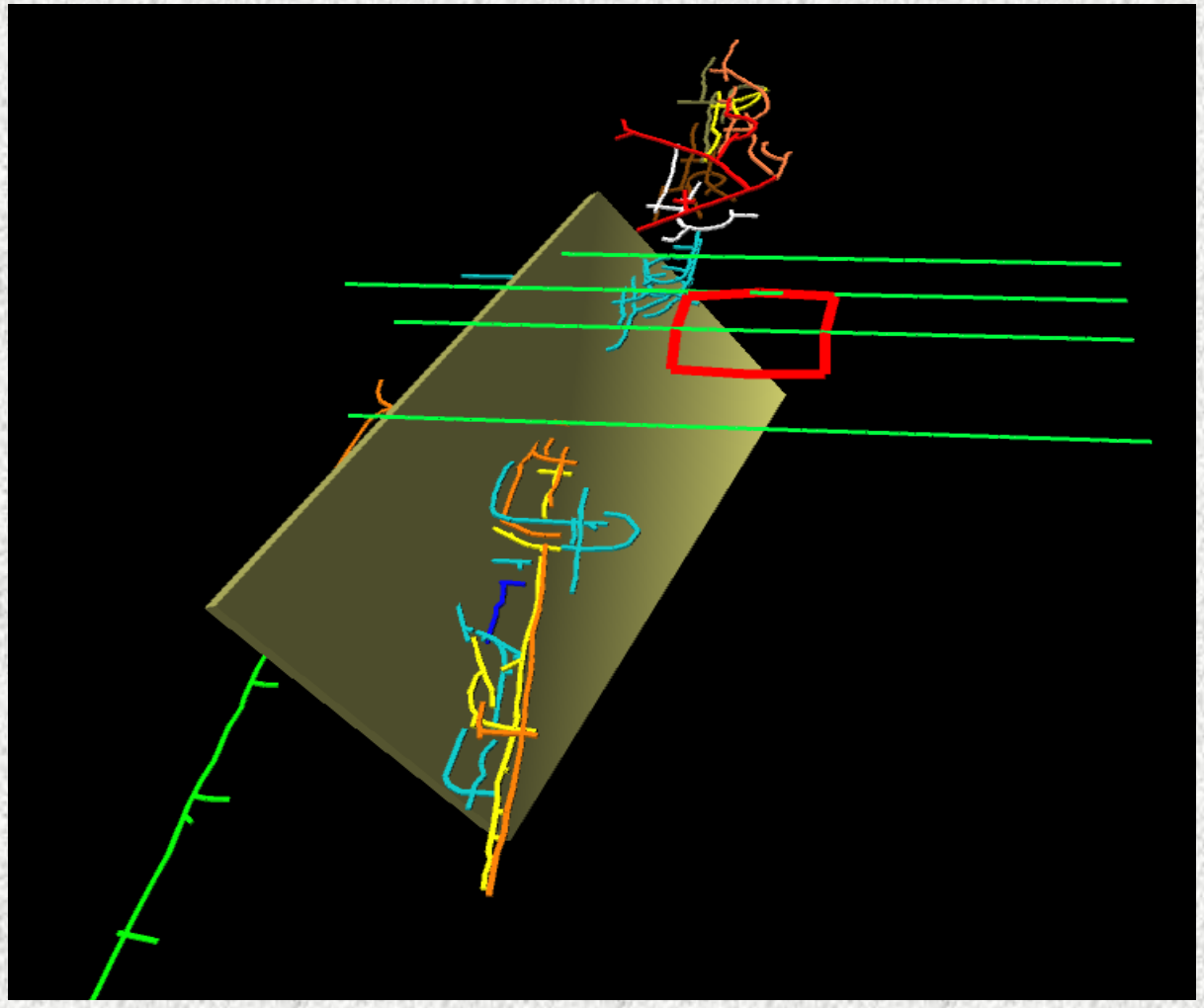


- **Aquifers Model: Ground Gravity and Airborne TEM**



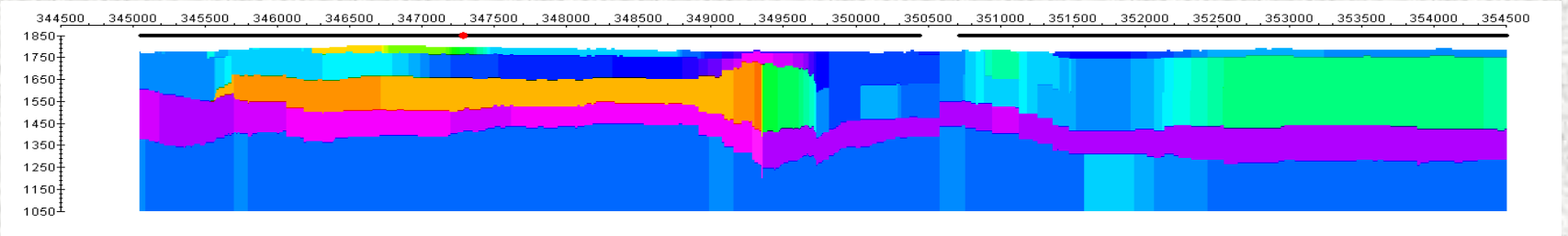
♦**Gold bearing sulphide zone CAD model**

TDEM target models with boreholes

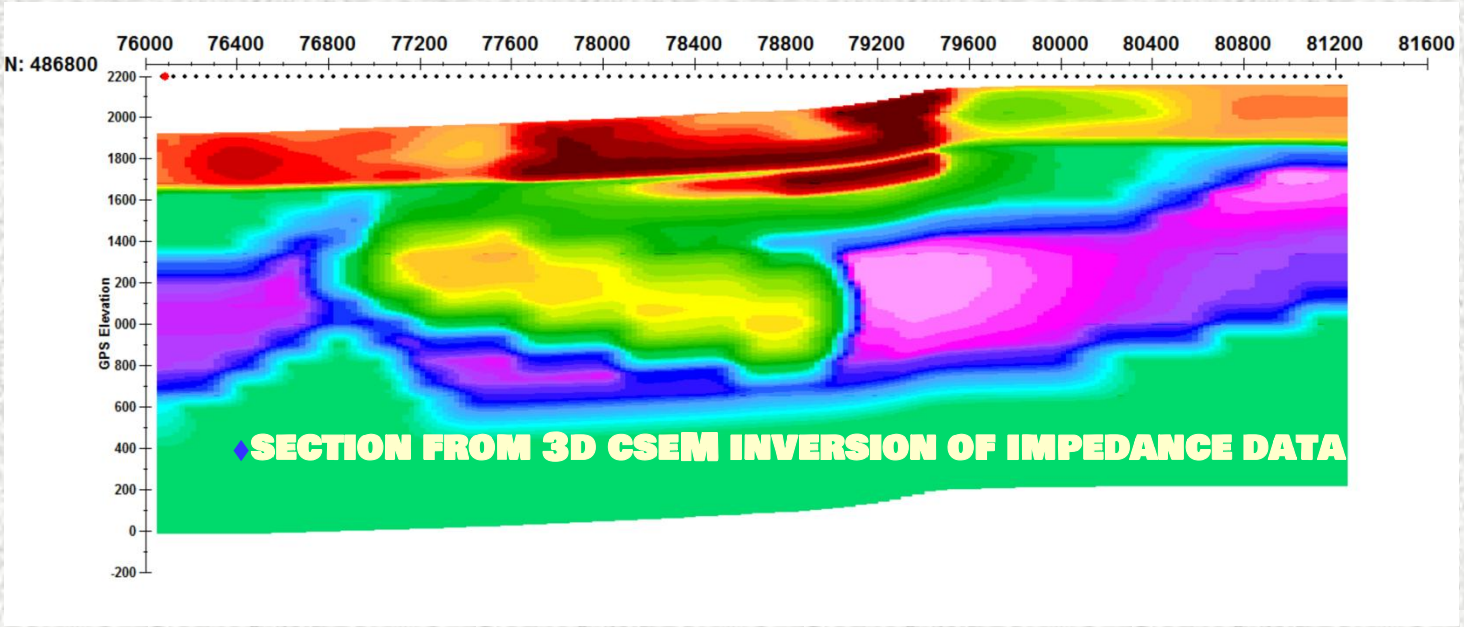


Ground TDEM Survey

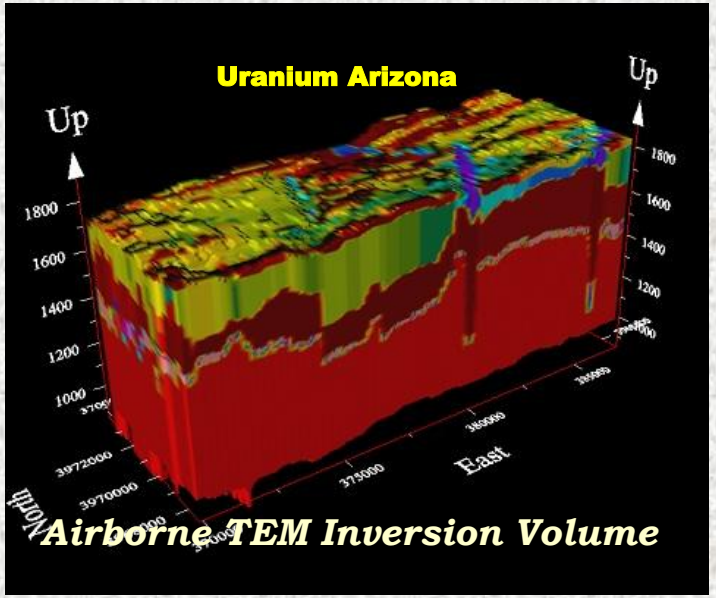
Underground Workings Shown with TDEM model

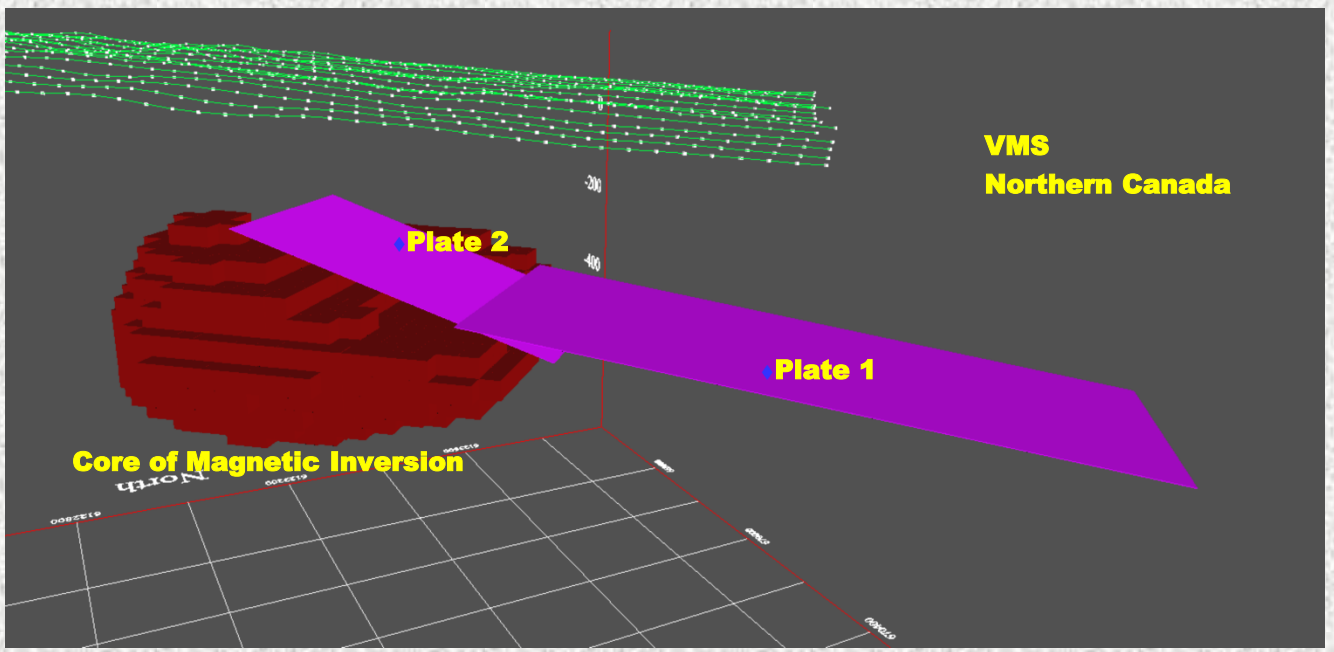


Airborne 1D Stacked TDEM Inversion

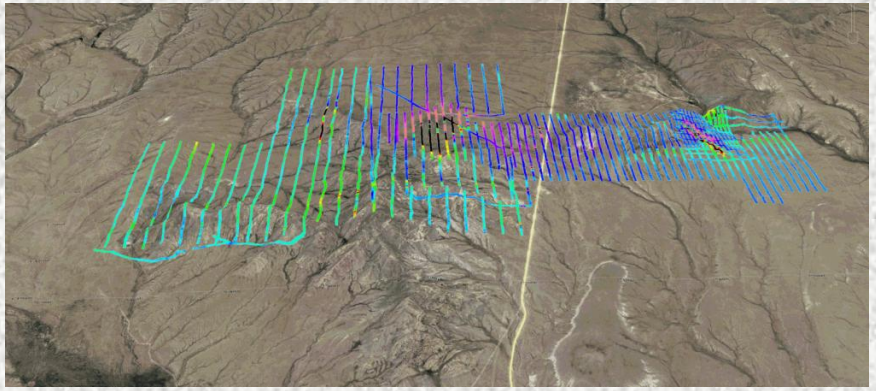


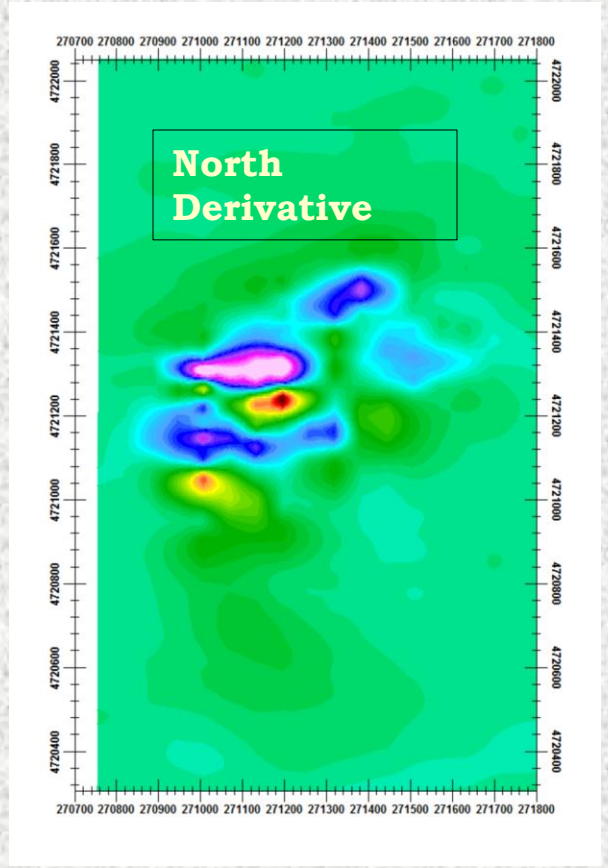
Visualization Tools

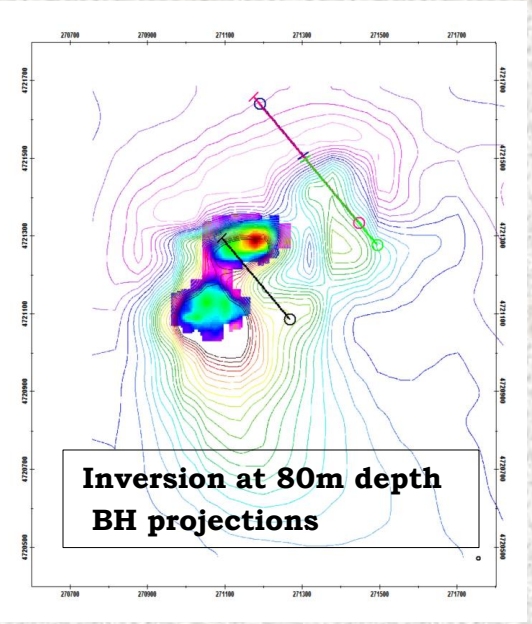


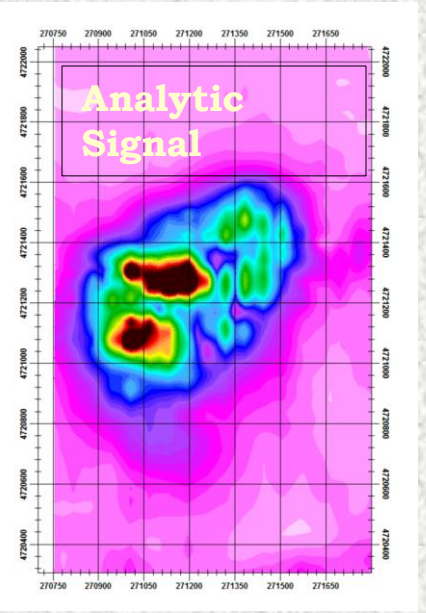


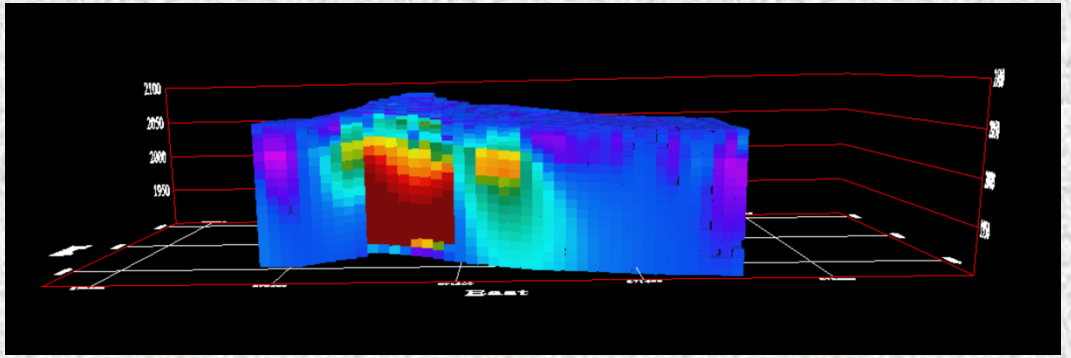
Ground magnetics VMS



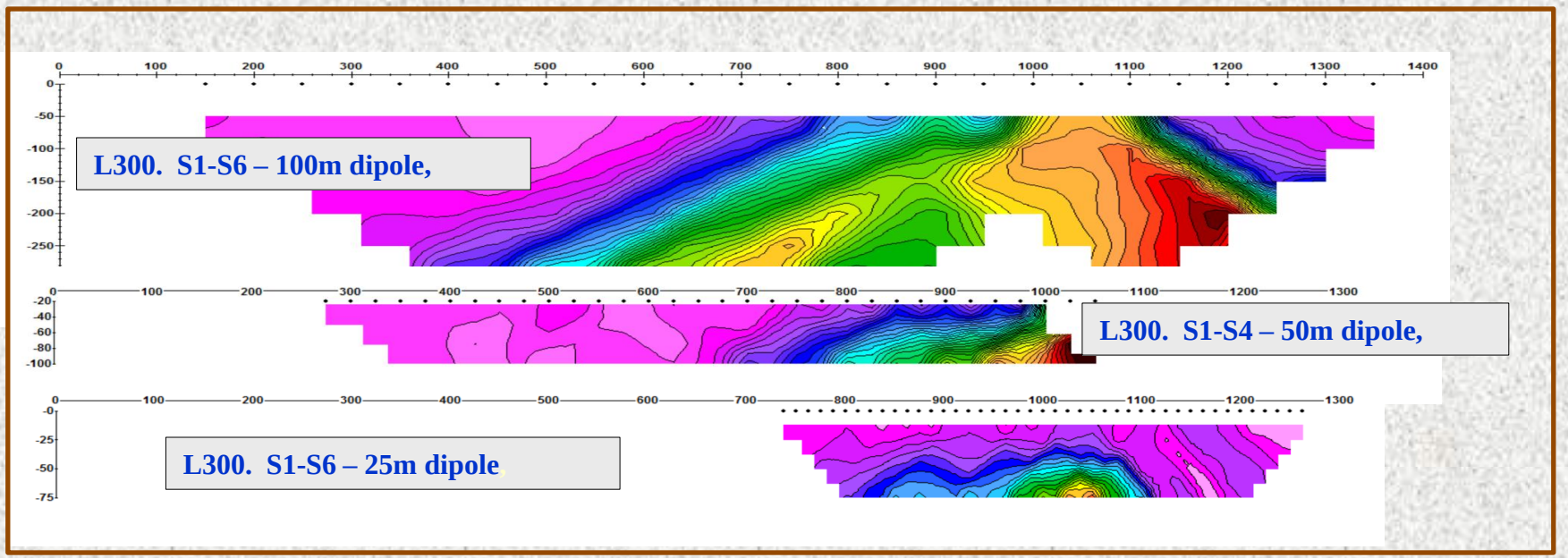


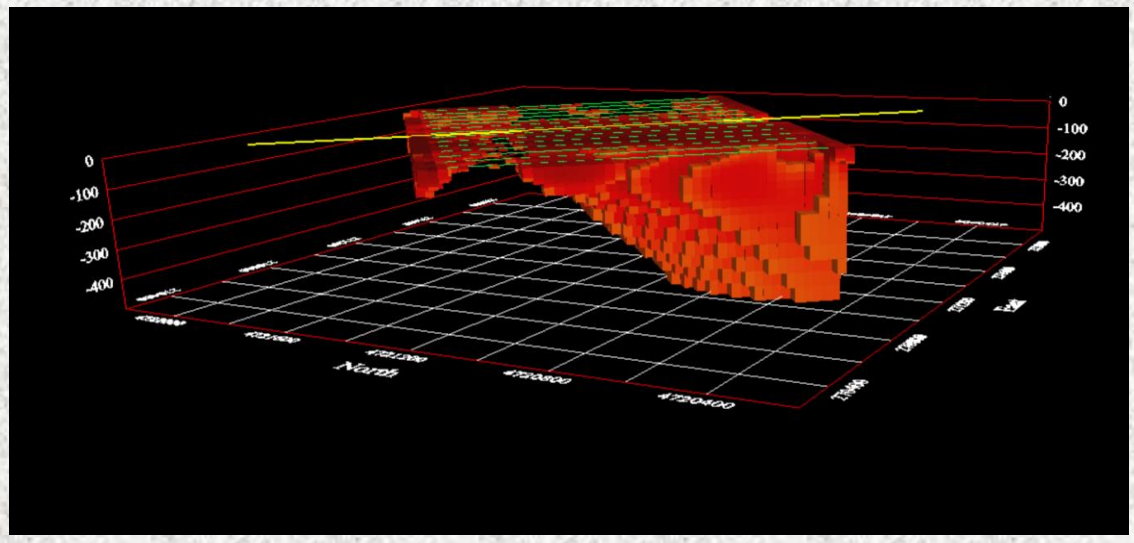






Resistivity Inversion Capabilities





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