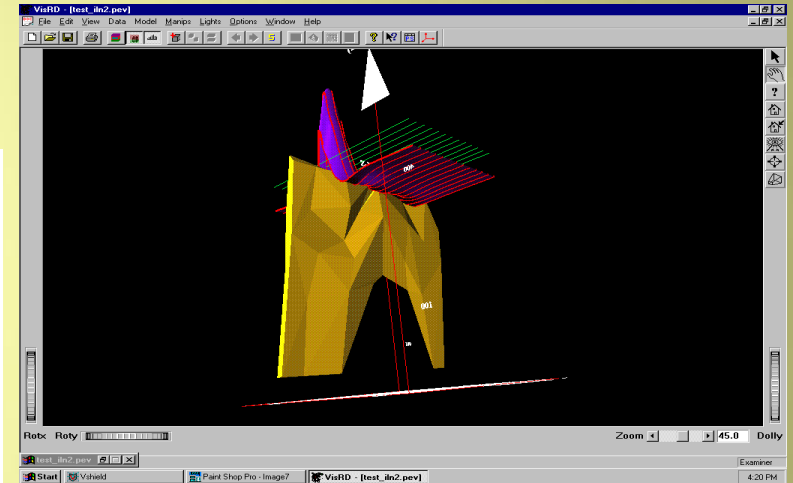
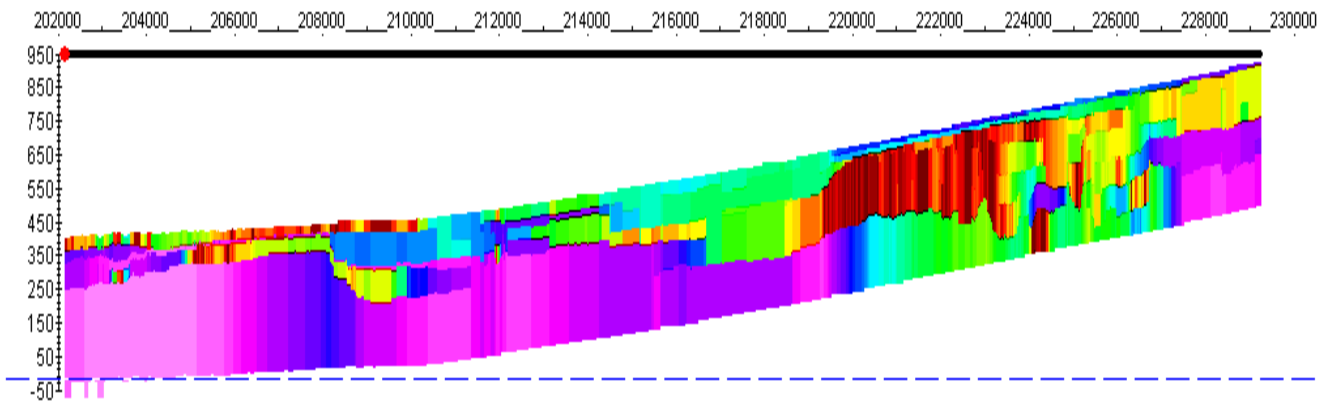


Eikon Technologies (Earth Imaging)

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

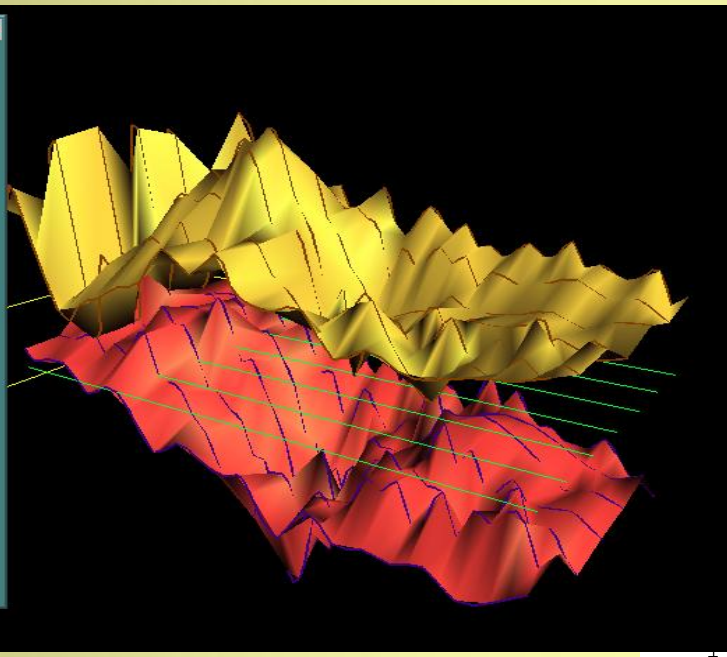
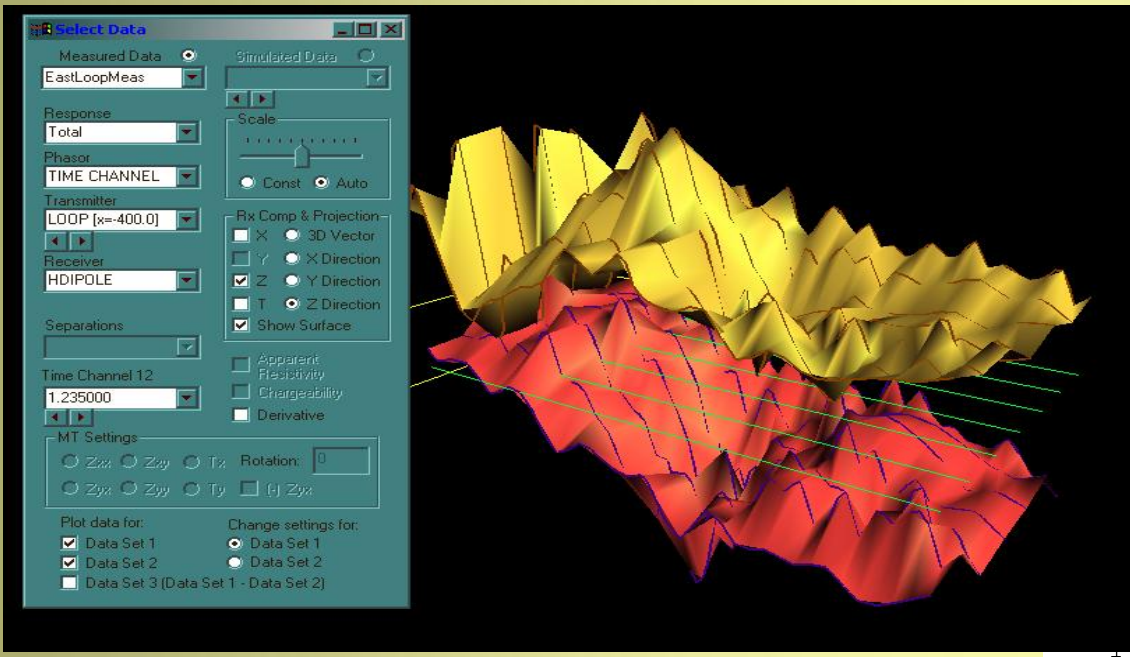
Aquifer study



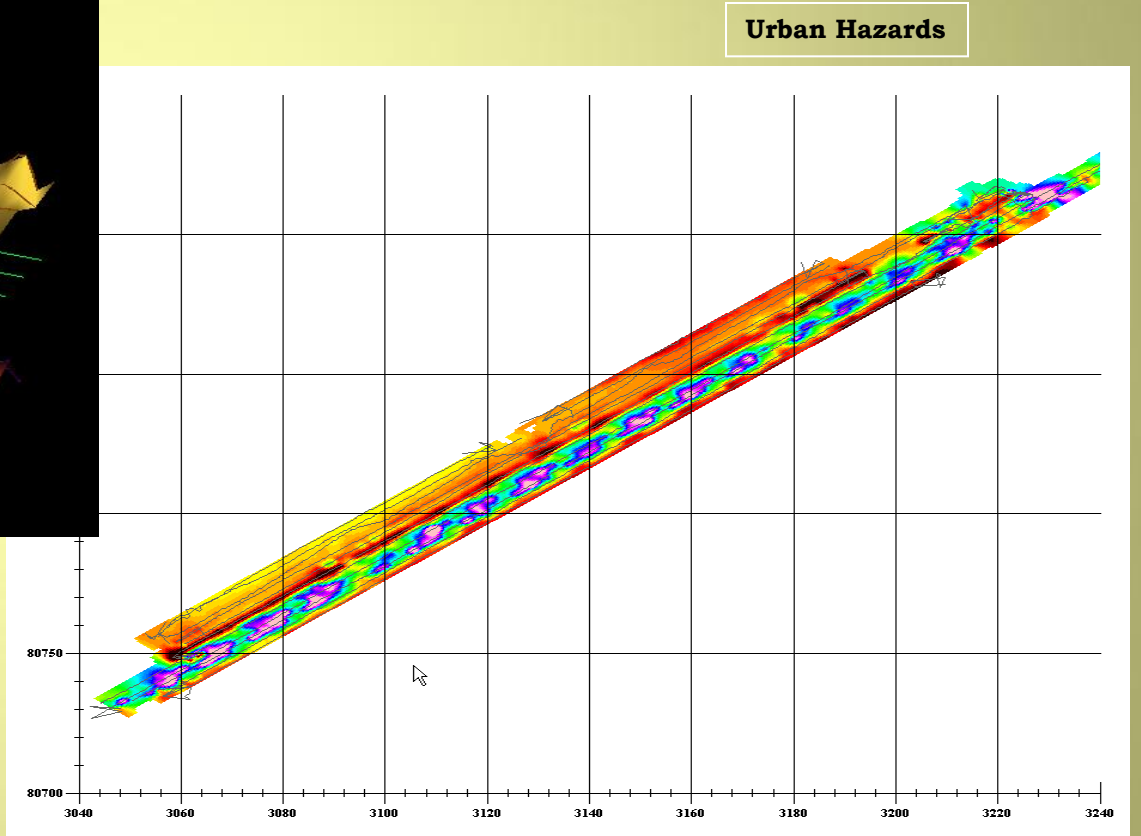
Ni/Zn Deposit



Developing Software for Interpretation of Geophysical Data Since 1994

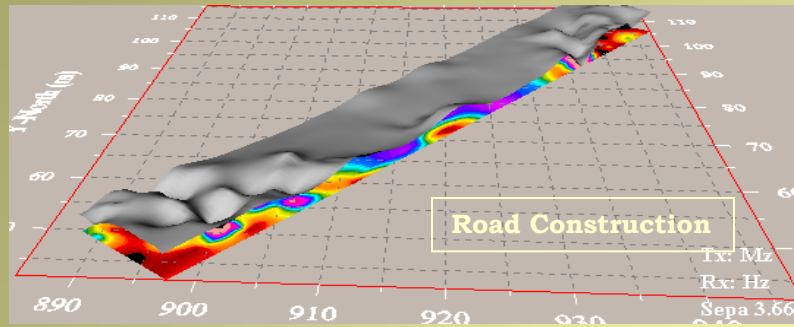


Uranium Exploration



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

Design Aim:

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

❖ Data Types

- ❖ EM, Resistivity, IP, Magnetics, CSAMT, MT, MTEM, CSEM
- ❖ Gravity

Survey Styles

- surface
- airborne
- surface to borehole

➤ borehole to borehole

* not all combinations available

Data analyses and editing 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

3D Magnetic Inversion, 3D Gravity Inversion

3D Resistivity Inversion

3D MT Inversion, CSAMT, land-based CSEM Inversion, ZTEM

1D FEM, TEM, Resistivity, CSEM, MT, CSAMT Inversions

FEM, TEM, Resistivity Pseudo-Depth and Goelectric 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 gridding, non-planar gridding, constant drapes

Model Stripping

Potential field data transforms – filtering, continuation, RTP

Magnetic and Gravity Gradients

Magnetic Compensation

Xhole Tomography

Gravity – 3D Modeling and Inversion

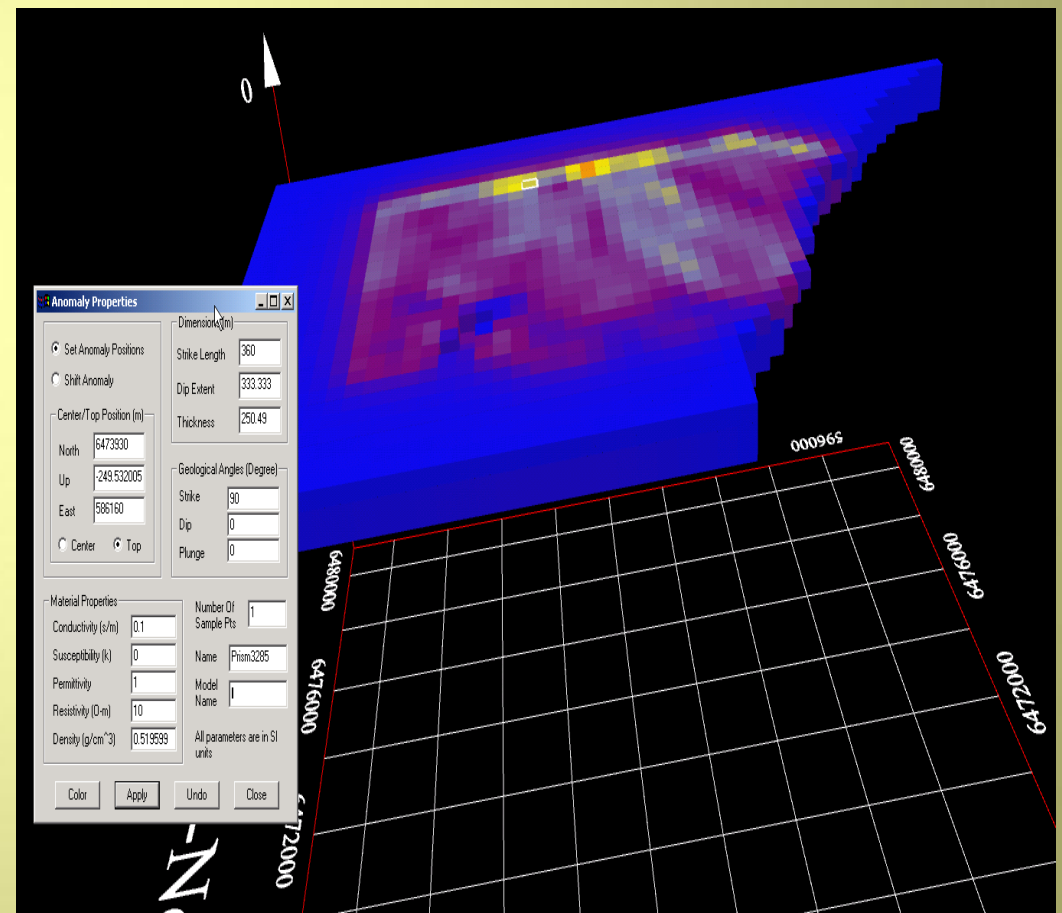
3D Euler and Post-Processing including 3D Visualization

FFT tools

(basic data processing also available)

EMIGMA Tools

Ground Gravity Inversion



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

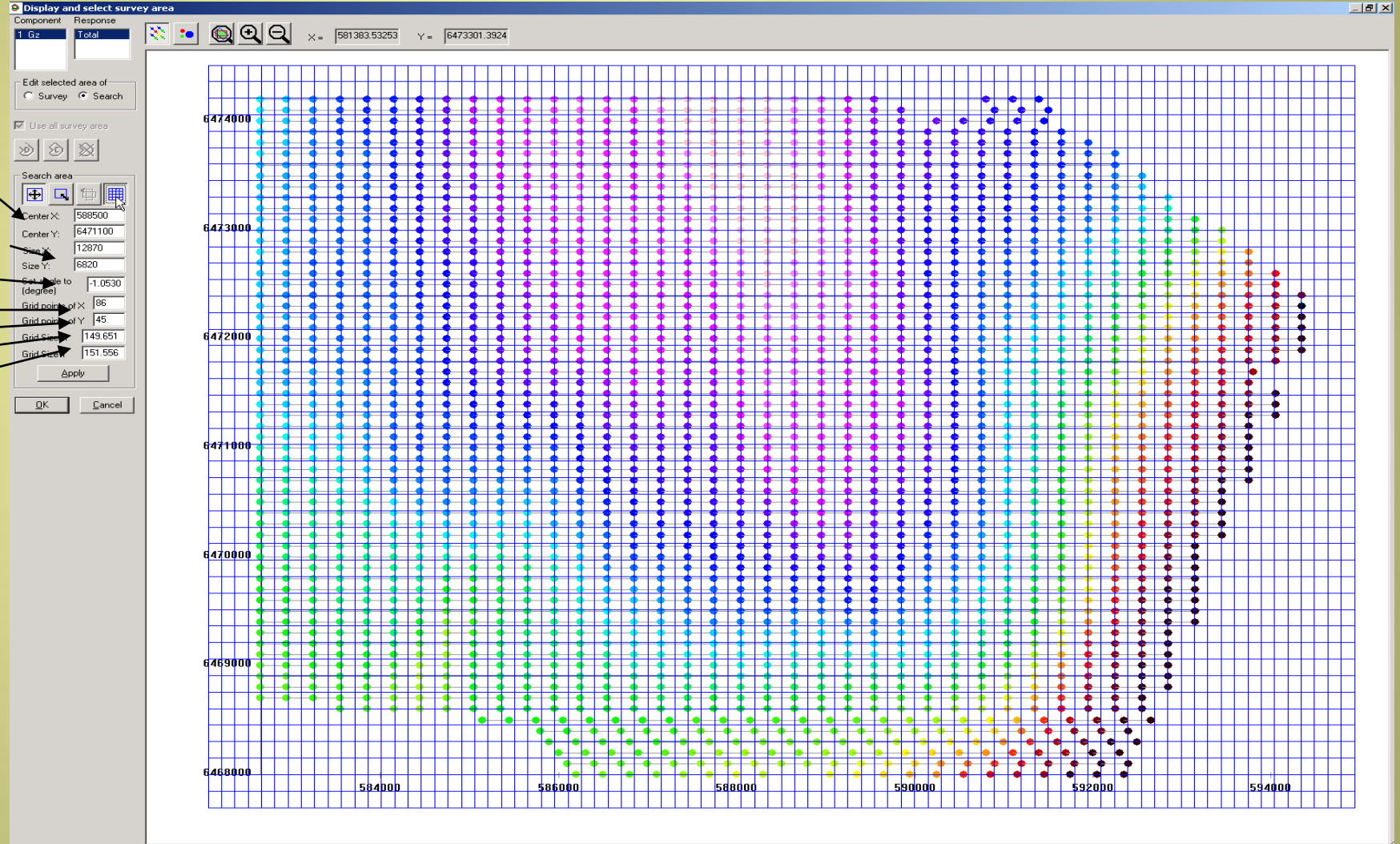
angle of grid

Nx in grid

Ny in grid

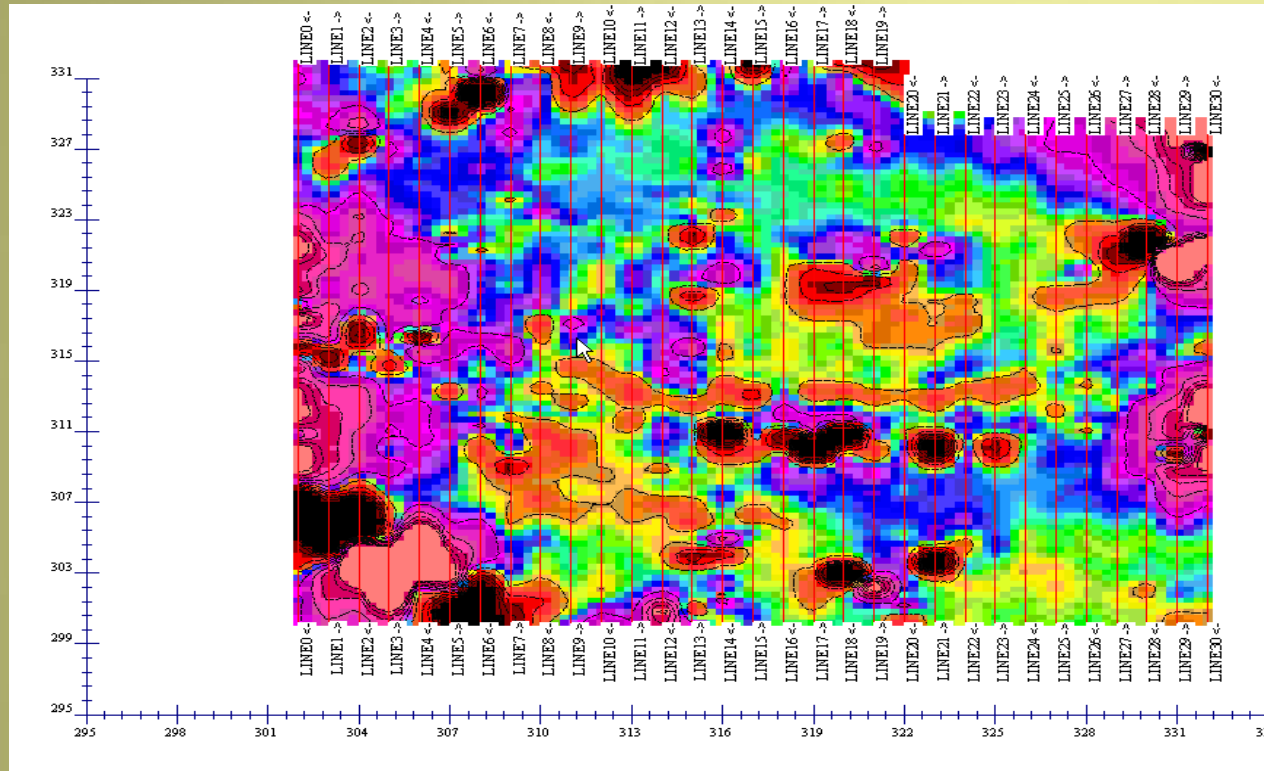
dX in grid

dY in grid

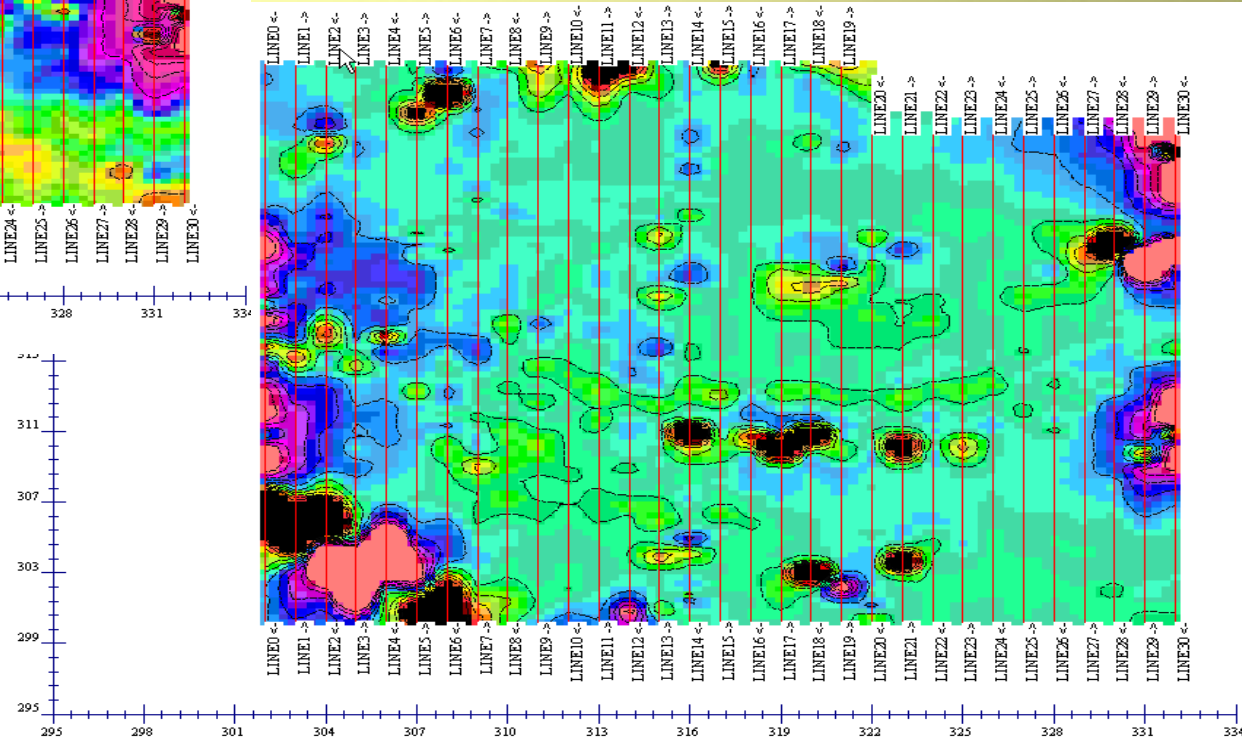


Data Interpolation and Contouring 1

Natural Neighbour, Shepard, Delaunay - Local
Minimum Curvature - global

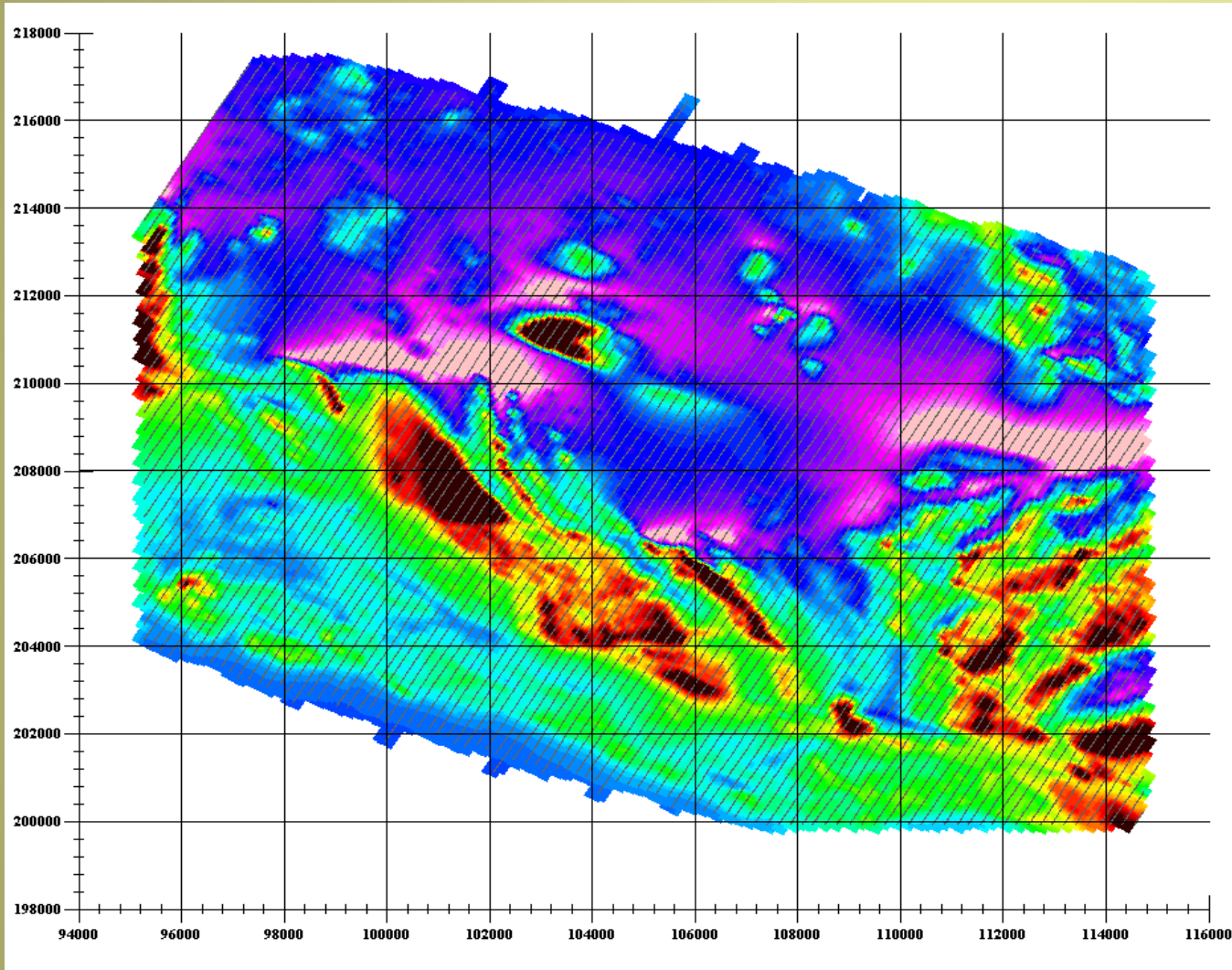


Rectangular grid cells
Multi-component grids
Equal Weight



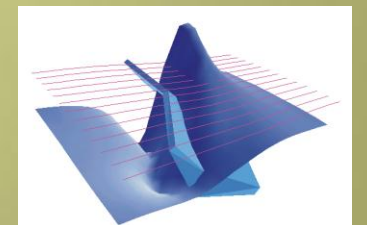
Equal Range

Data Interpolation and Contouring 2



Massive Sulphide Exploration – Spain/Portugal

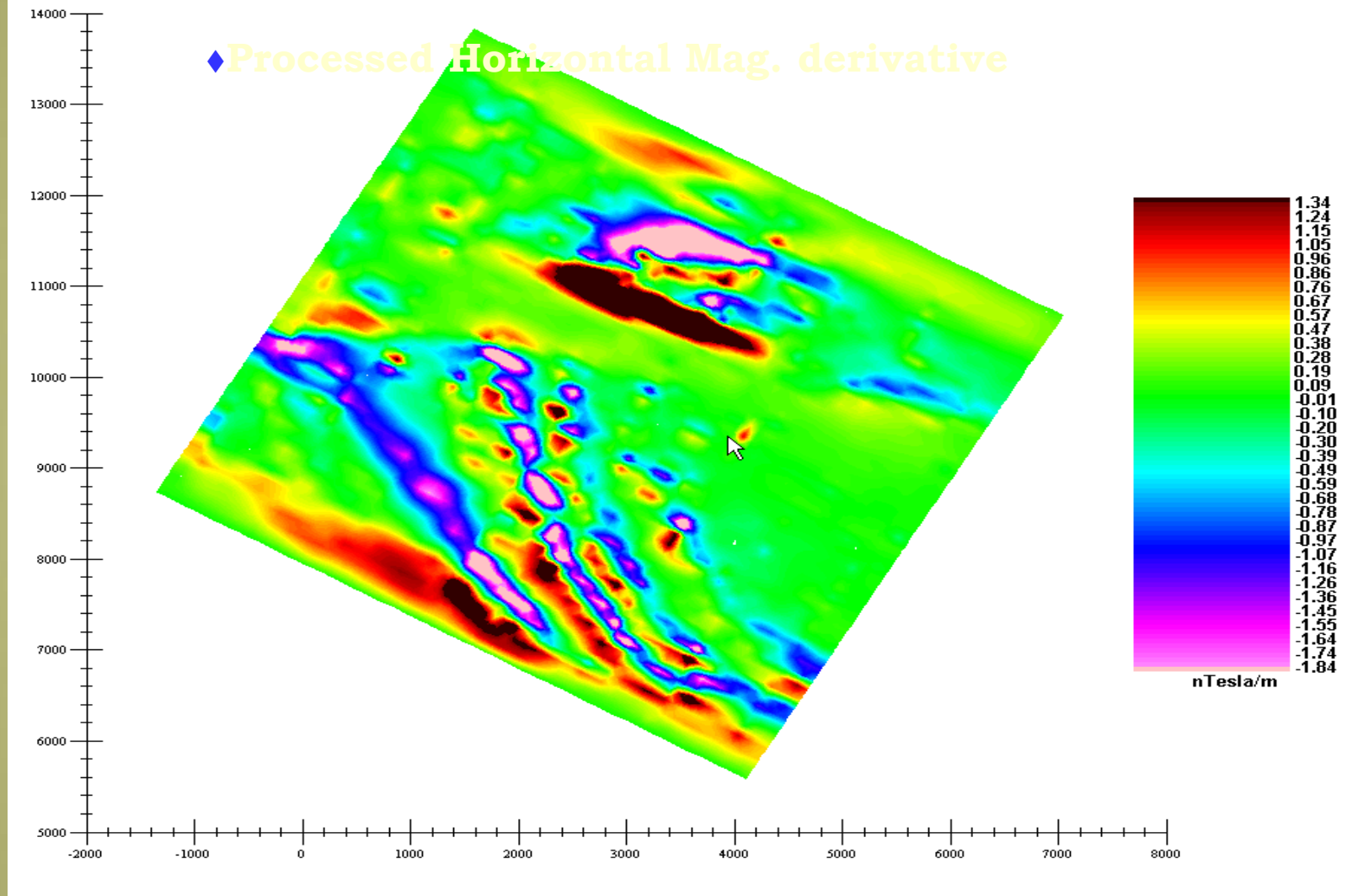
- ✓ **Natural Neighbour Interpolation**
- ✓ **Delaunay Triangulation**
- ✓ **Shepard**
- ✓ **Minimum Curvature**
- ✓ **Splines**



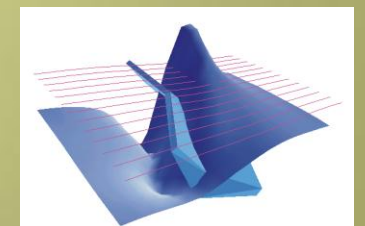
Data Interpolation and Contouring 3

◆ Processed Horizontal Mag. derivative

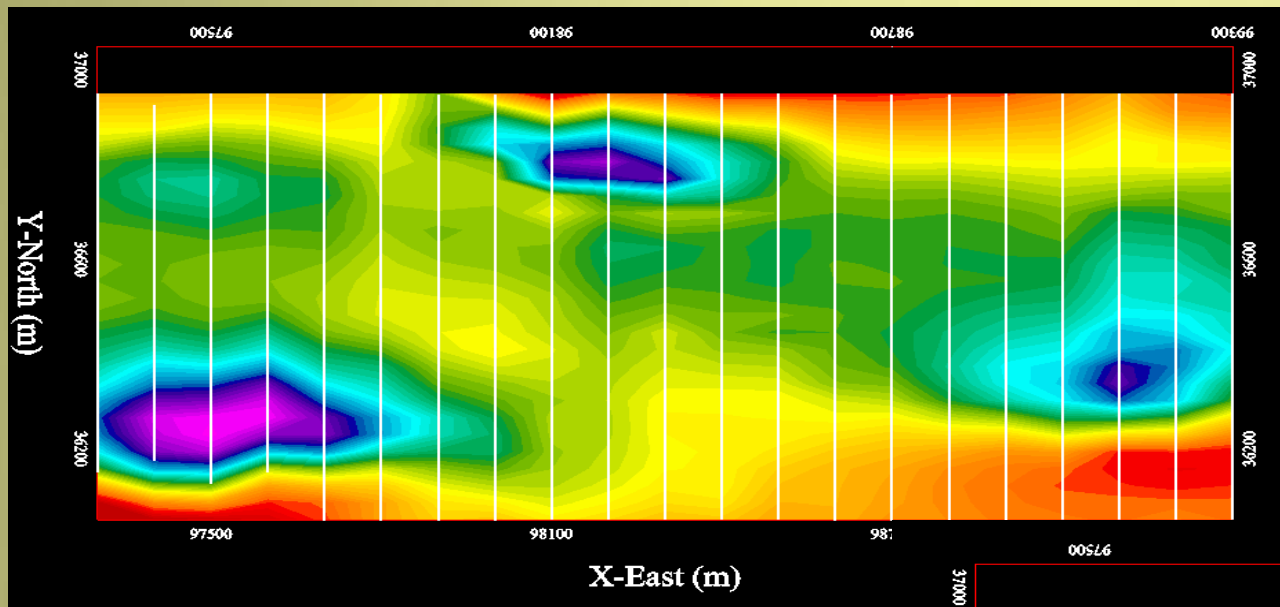
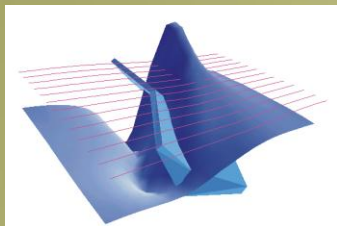
Grid View



Multiple datum stored in a grid for quick viewing

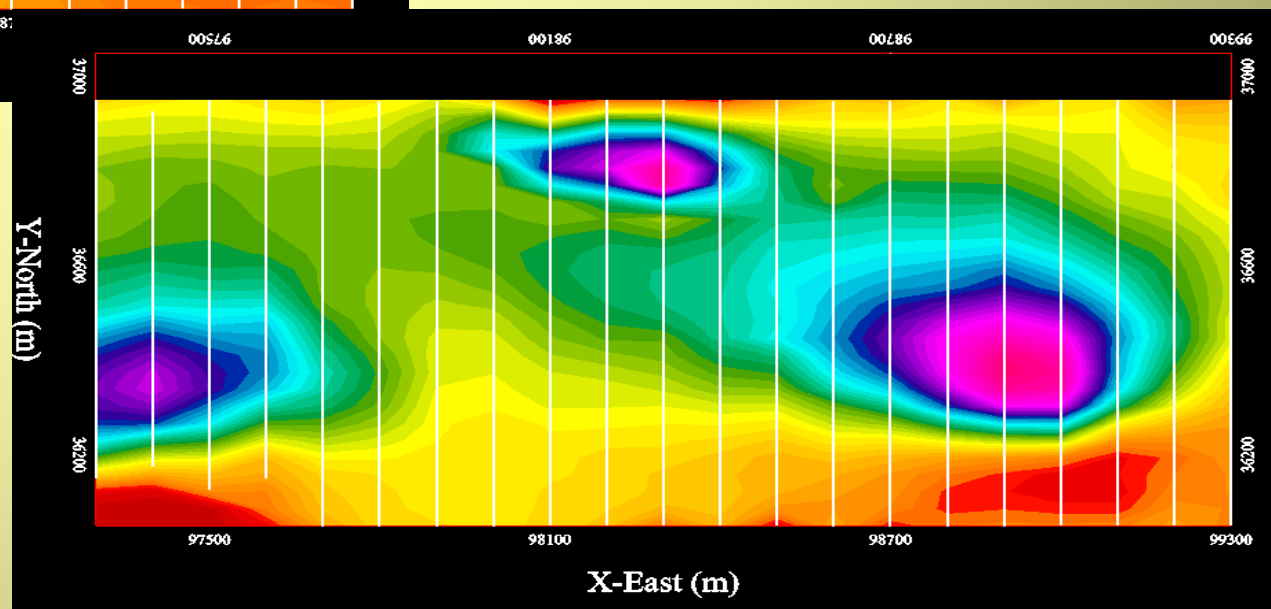


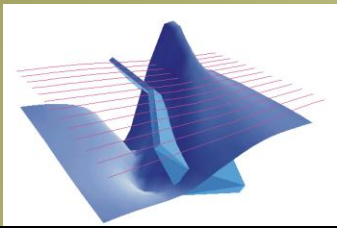
Track anomaly time evolutions



**Mid-Time
TEM data**

**Late-Time
TEM data**

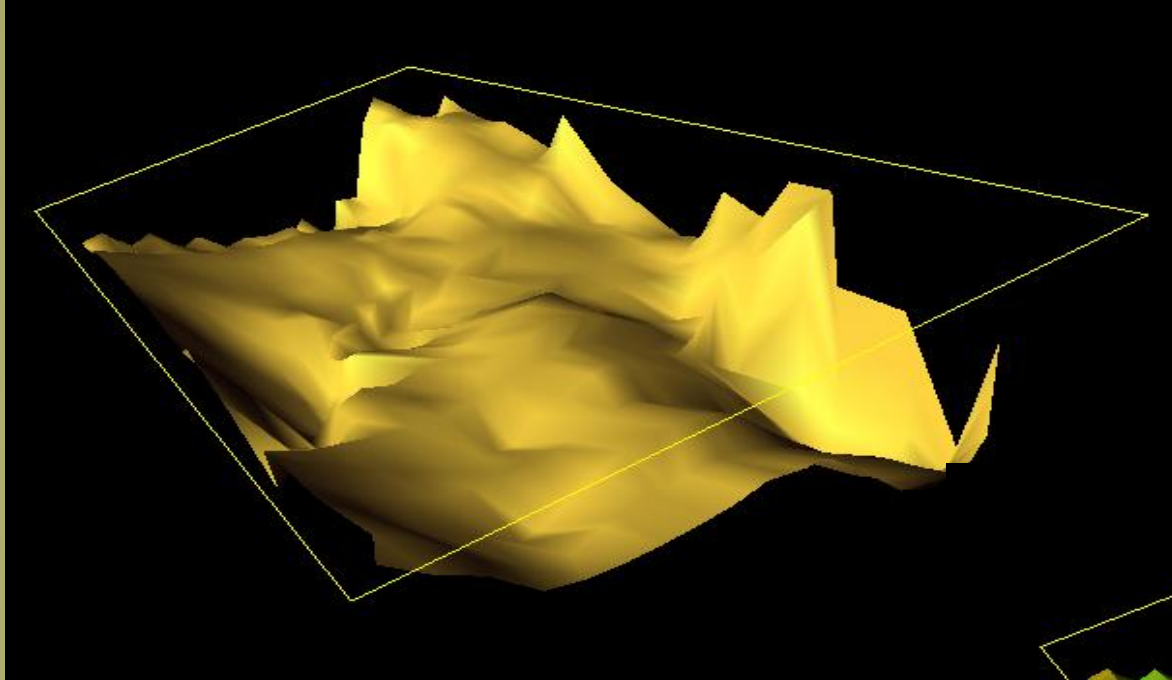




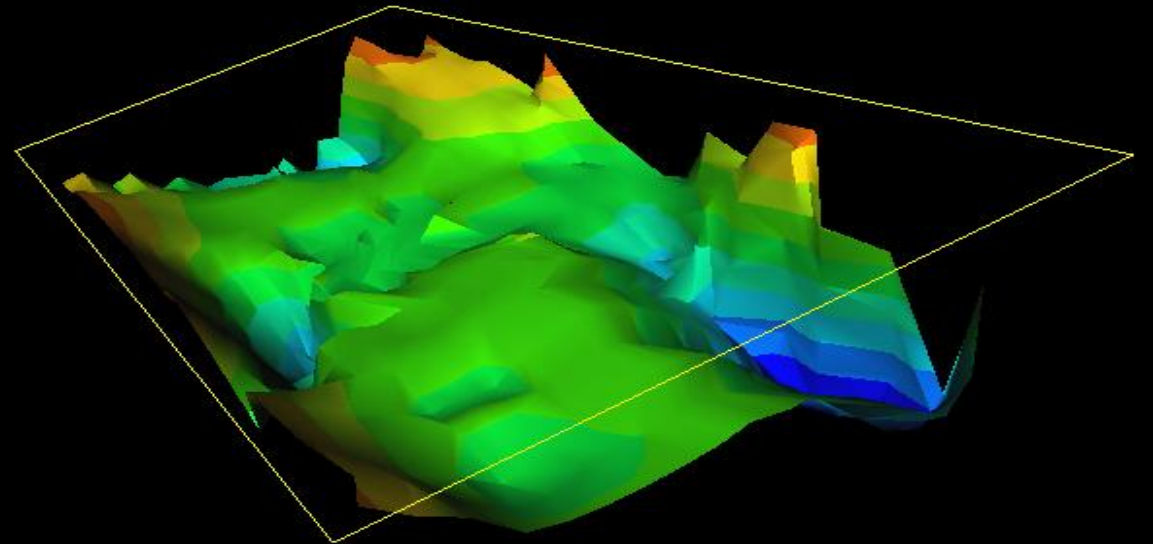
Surface representation of data allows for a spatial display of anomalies

Data Surface

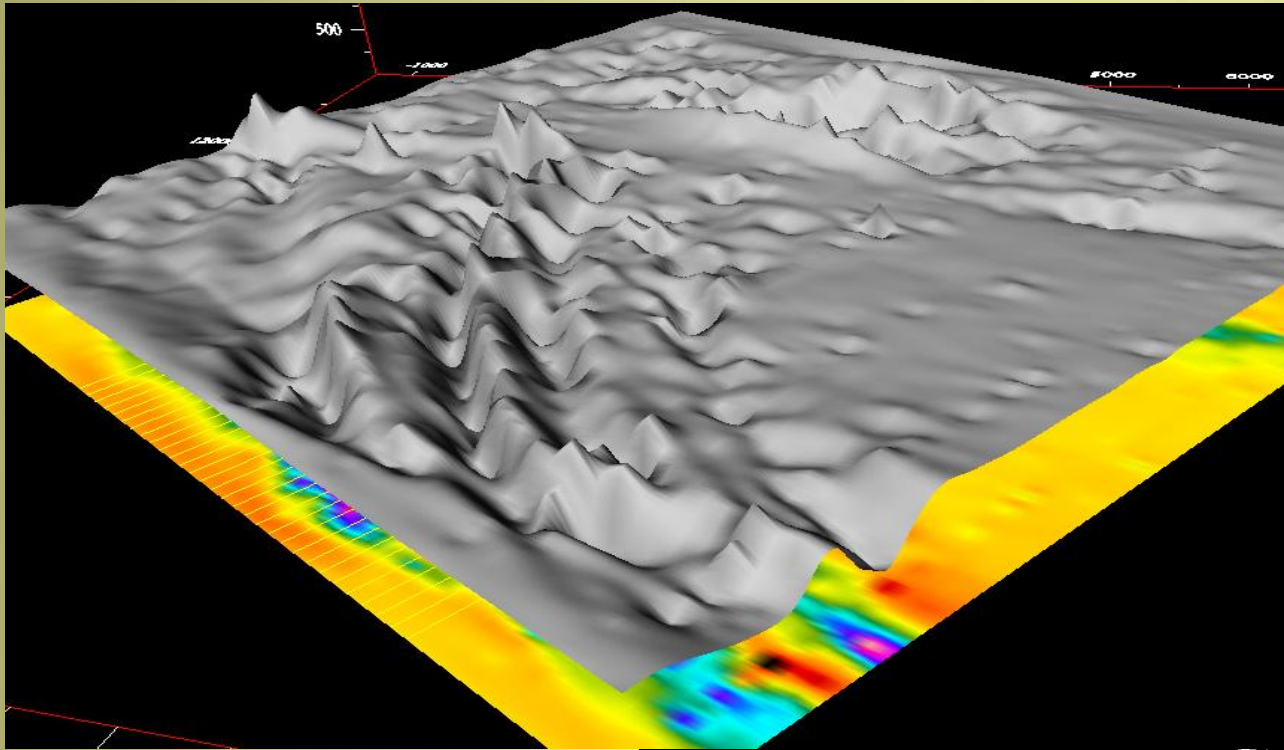
Nickel Exploration – Canadian Arctic



**Contoured
Data Surface**

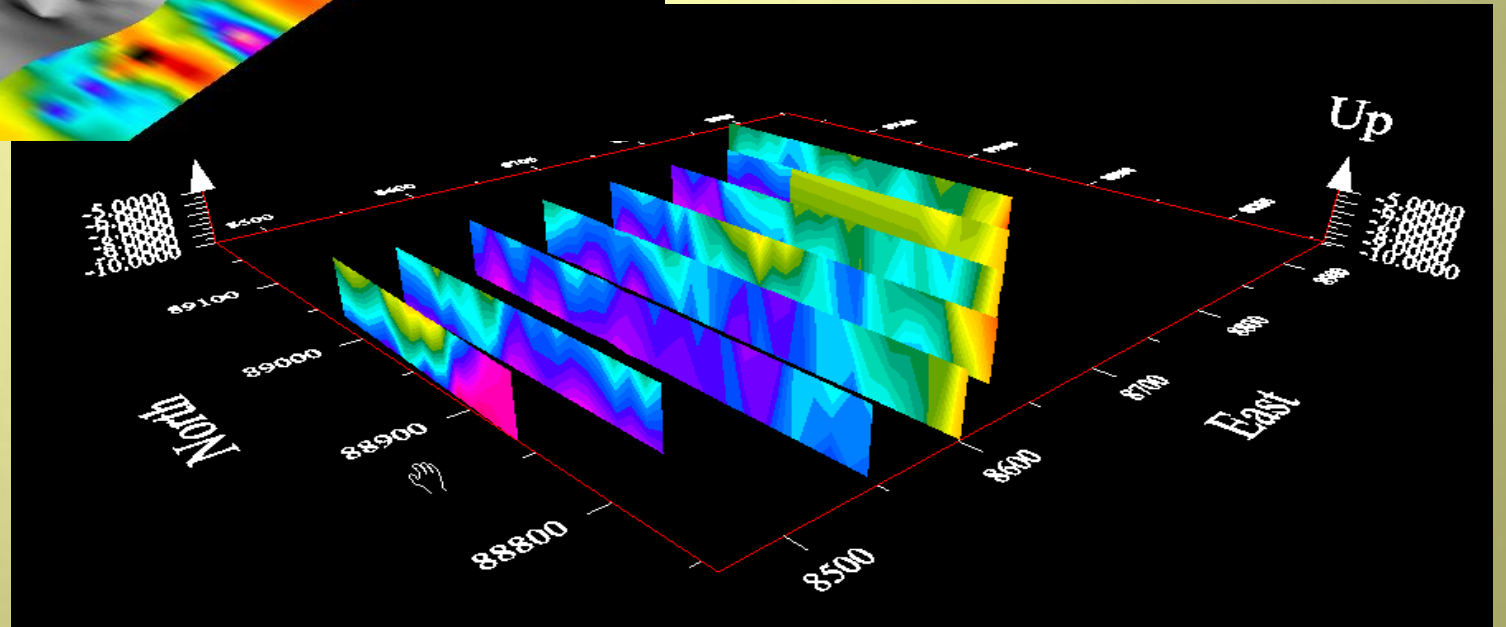


Data Interpolation and Contouring 4



Airborne Gravity – Gulf of Mexico

IP data - Mongolia

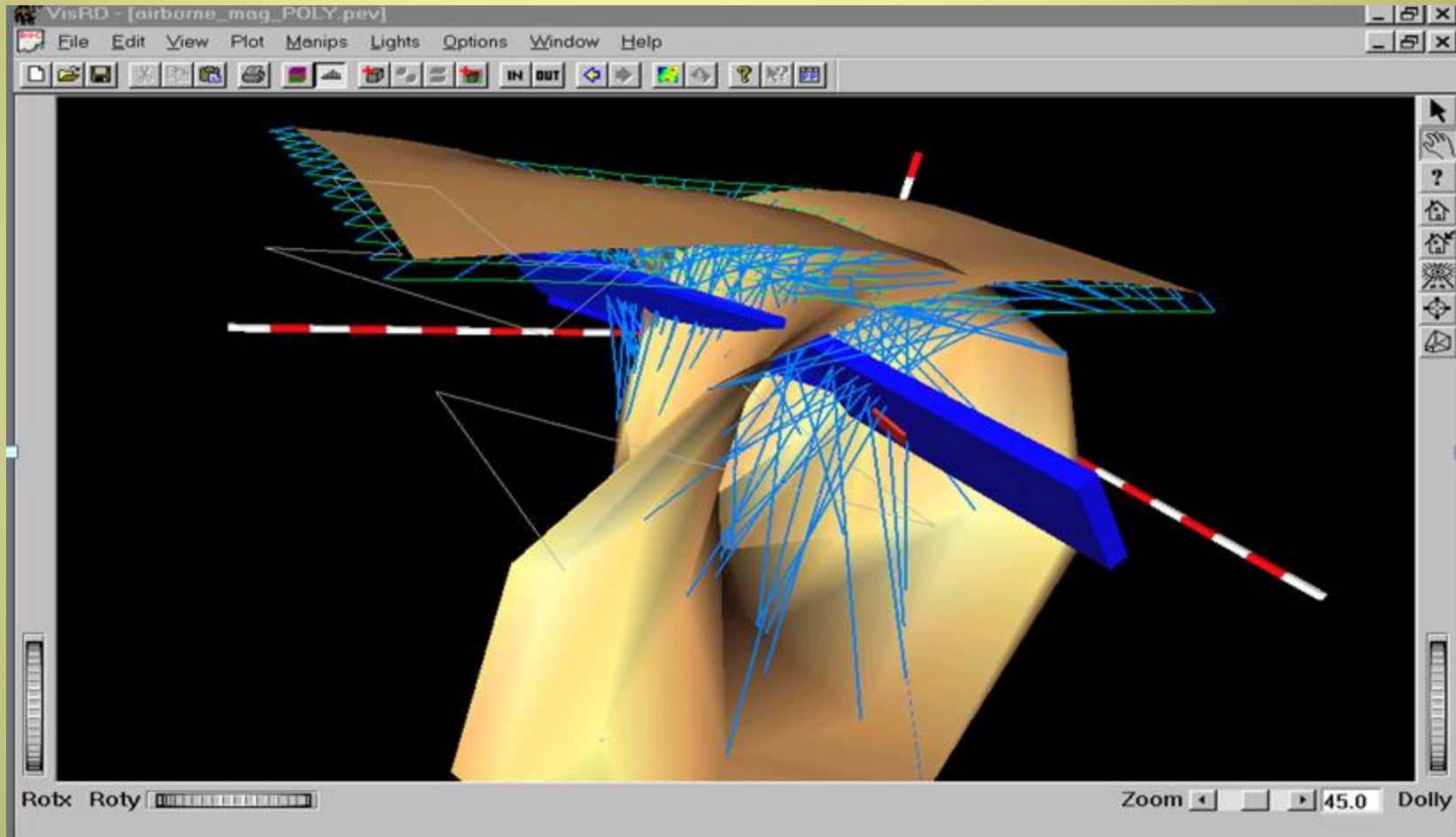


PETROSEIKON
Geophysical exploration

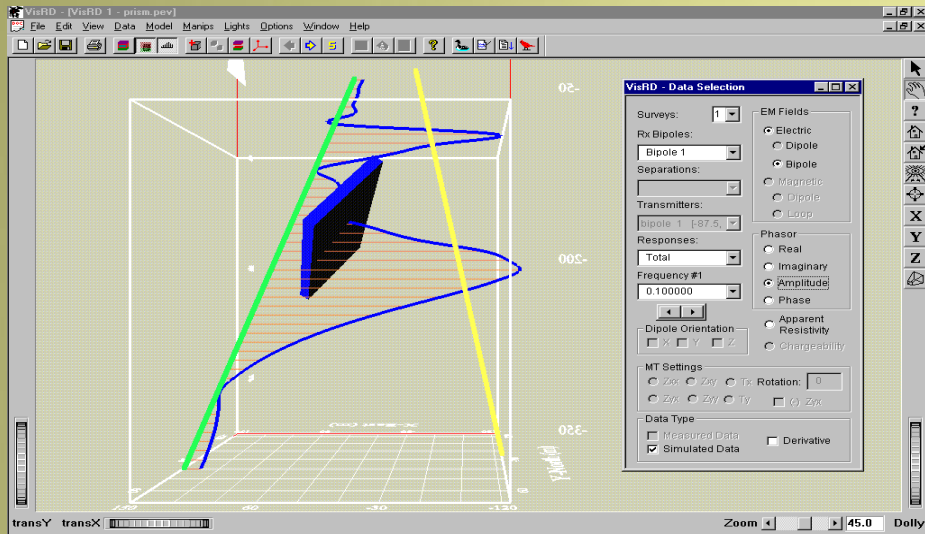


EIKON
TECHNOLOGIES

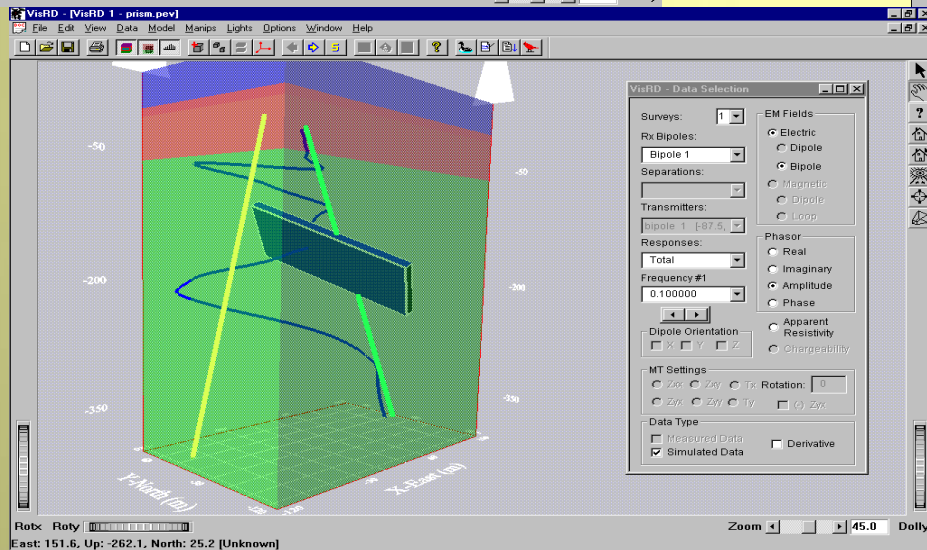
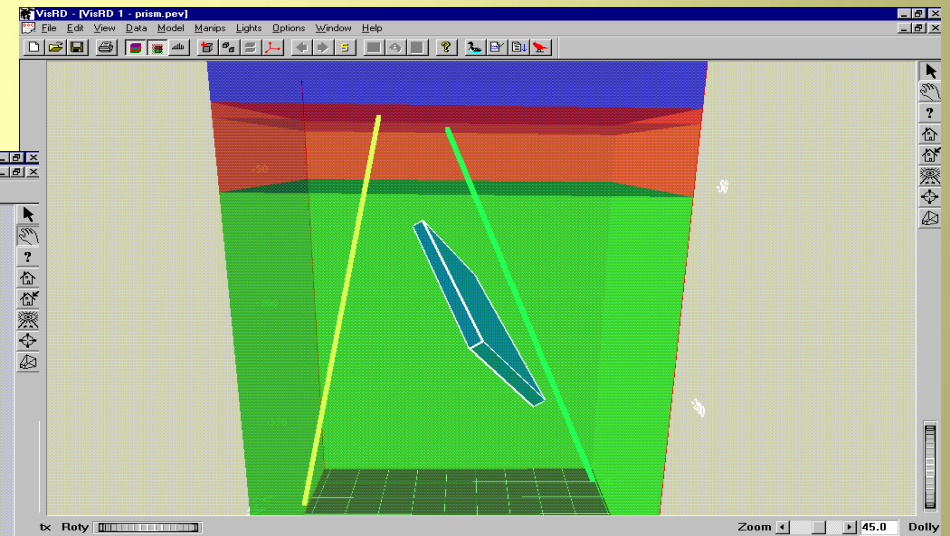
A Range of 3D Data Representations



Model Building and Simulation - 1



View survey, Build models and analyze data in 3D



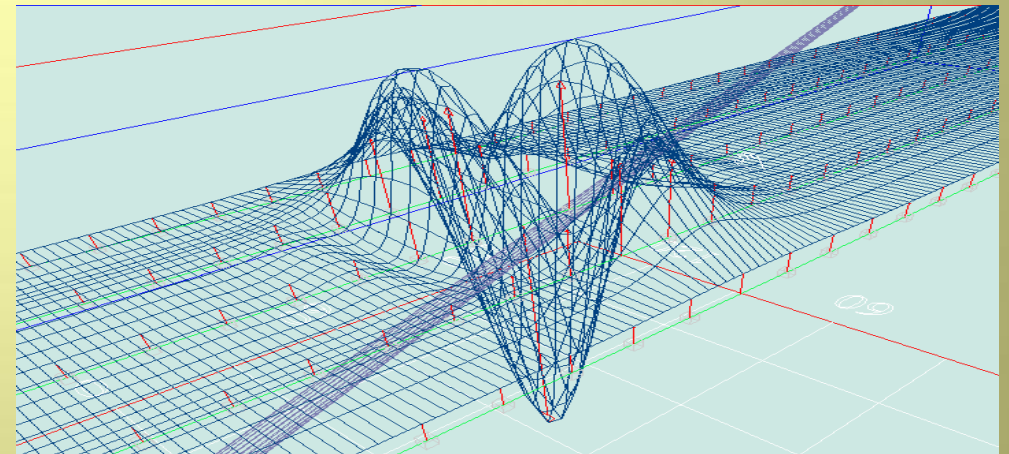
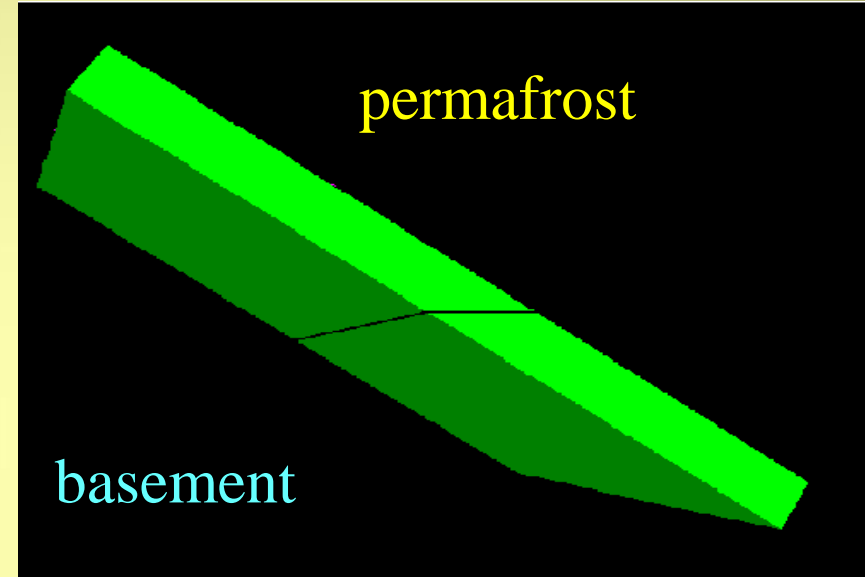
e.g. Crosshole resistivity survey and model – gold deposit delineation

Model Building and Simulation - 2

EM → TDEM and FDEM

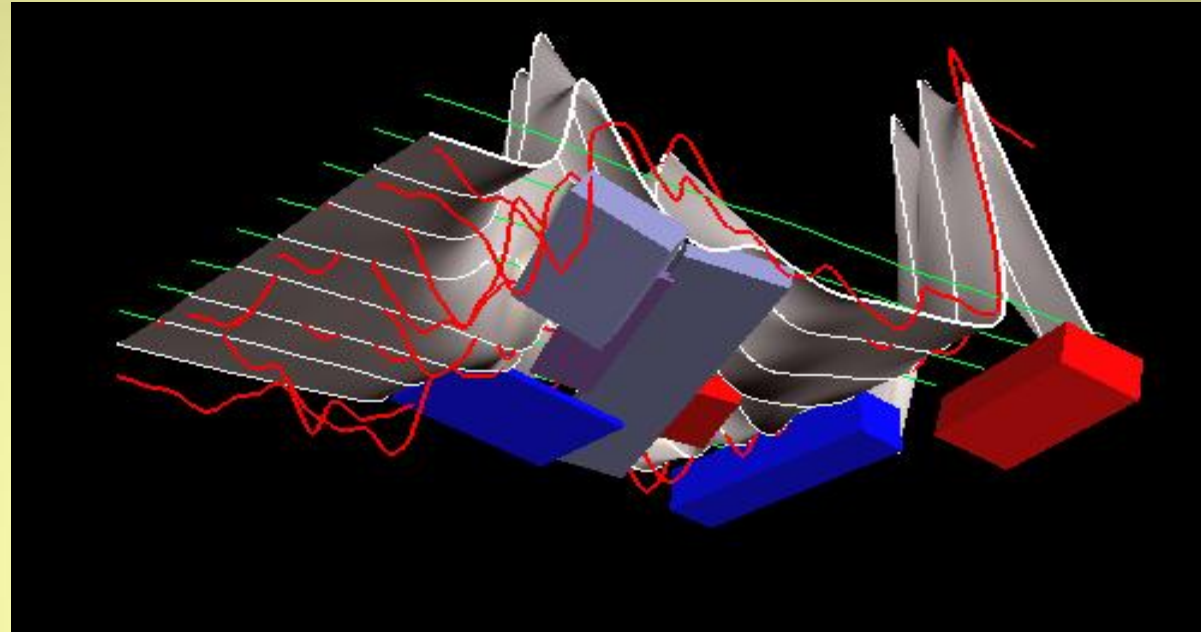
3 Algorithms – 3D integral equations in layered host

- Prisms, Plates and Polyhedra
- Strong and Weak Interactions
- Calibrated Impulse, Step and INPUT Waveforms
- Airborne, Ground and Borehole
- Fixed, Moving and Stepwise Moving Transmitter
- Pseudo-Section analyses
- Magnetic effects – magnetostatic and galvanic
- IP effects
- direct comparisons to measured data
- super-engine architecture for large models or surveys
- Model Suites
- Batch modelling



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

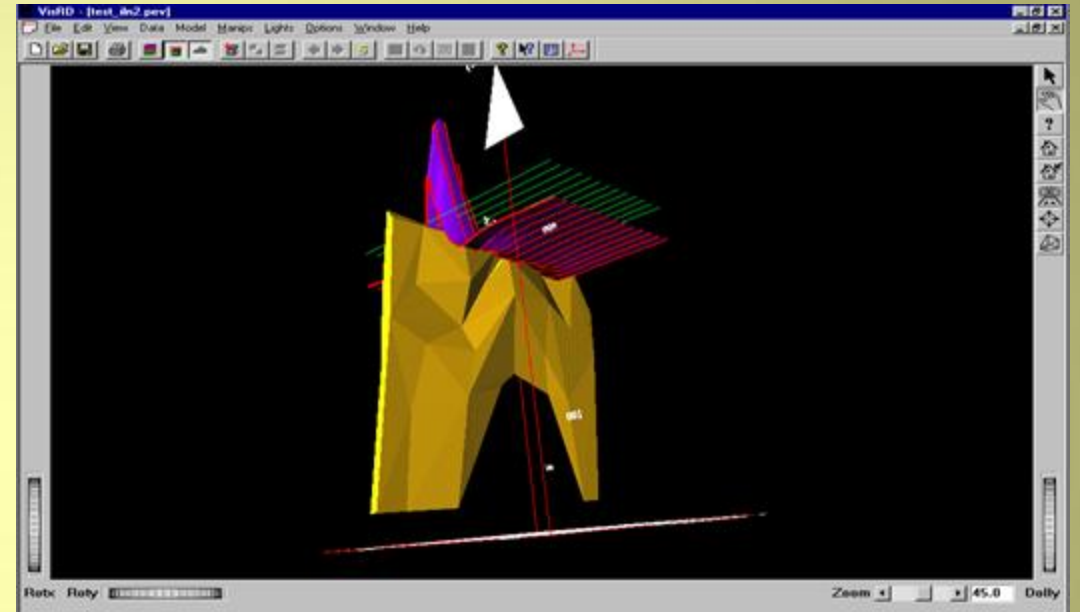
UXO cleanup



Model Building and Simulation - 4

IP/Resistivity/MIP

- **3D integral equation**
 - **Born (weak) and Strong (non-linear)**
- **Prisms and Polyhedra**
- **Strong and Weak Interactions**
- **TEM and FEM**
- **EM effects in IP (magnetic 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**



Model Building and Simulation - 5

Others

Gravity – 3D (Now available)

analytic and numerical integration – (total and vector field)

borehole modelling

gravity gradients (full tensors)

MT, CSAMT (3D)

impedances or fields

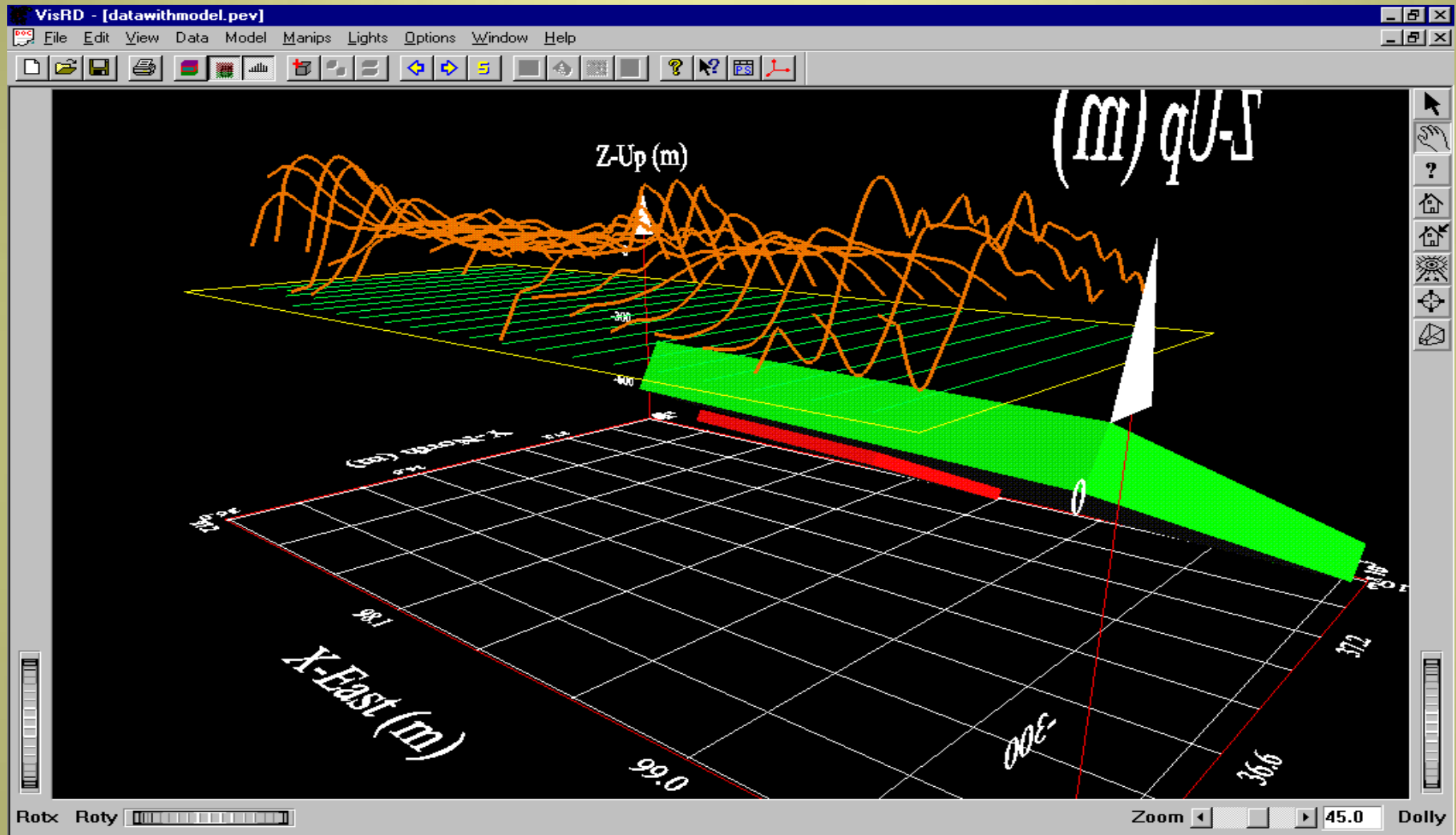
Strong and Weak Interactions

Crosshole

electric (3 antennae types) or magnetic antennae

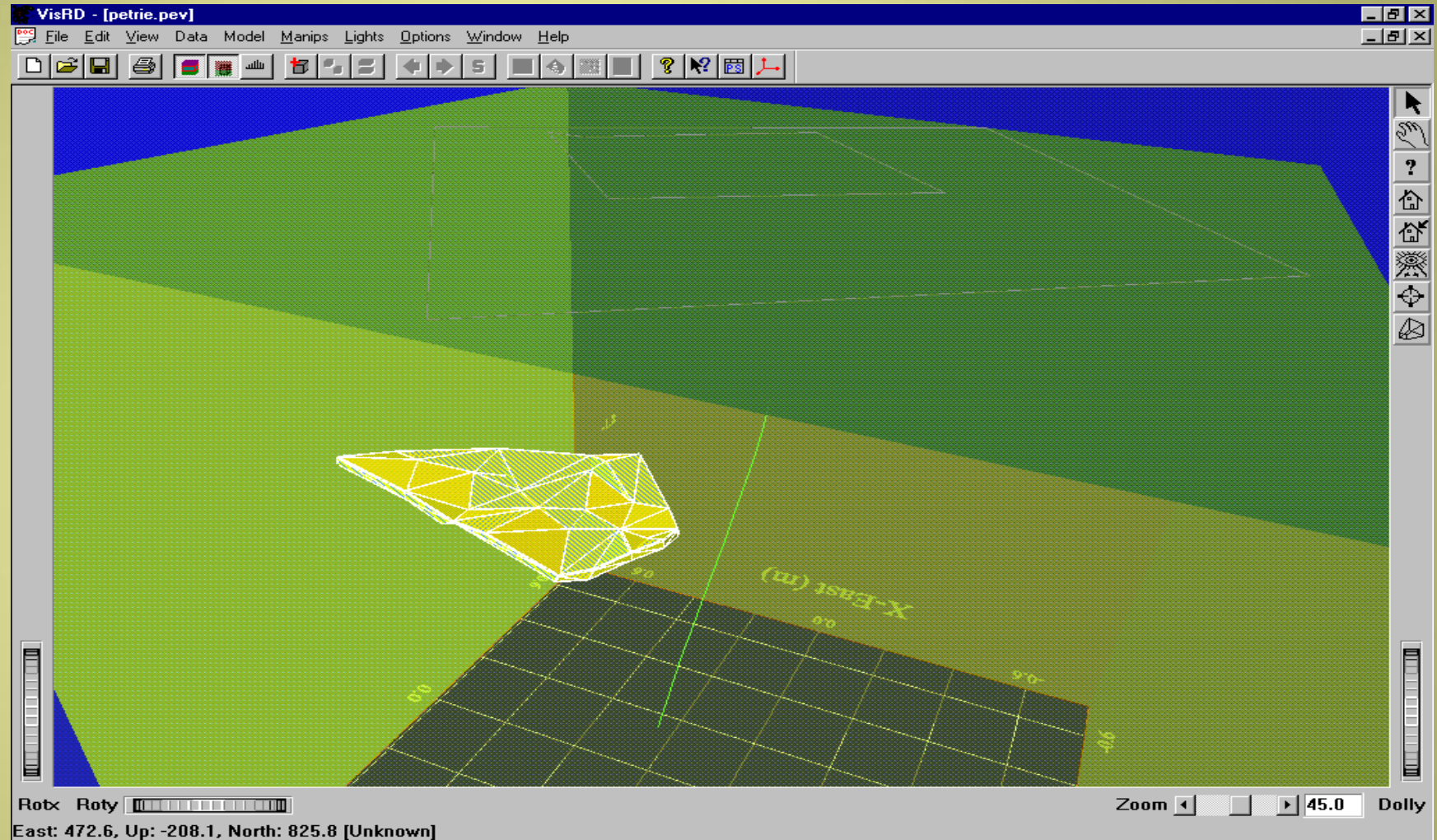
Experimental Systems

Data and Structure Representation in EMIGMA's 3D Visualizer



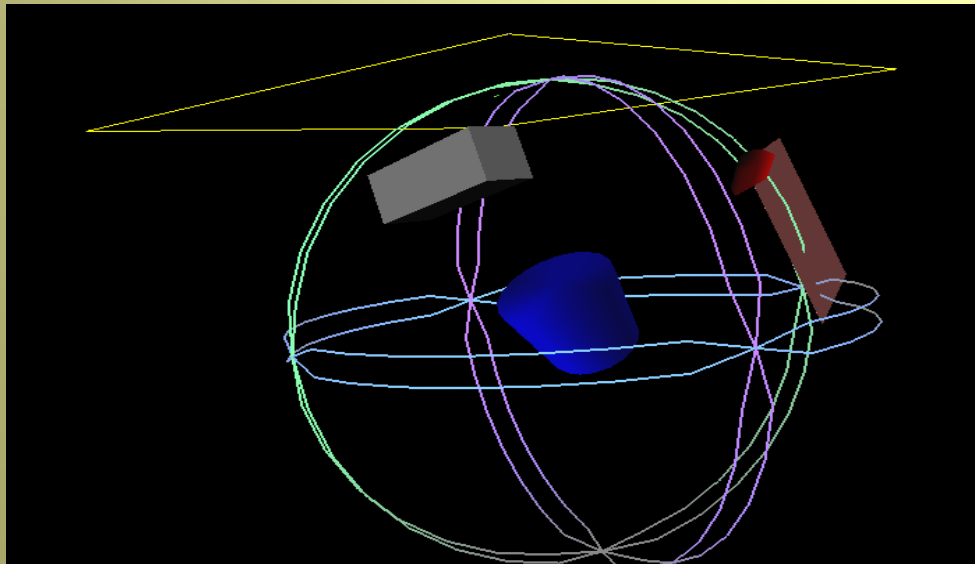
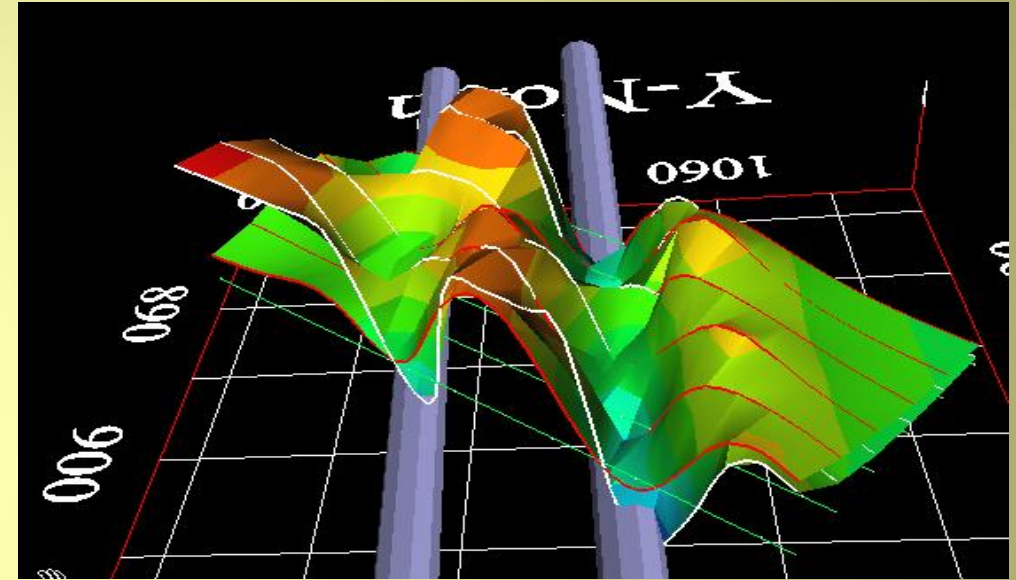
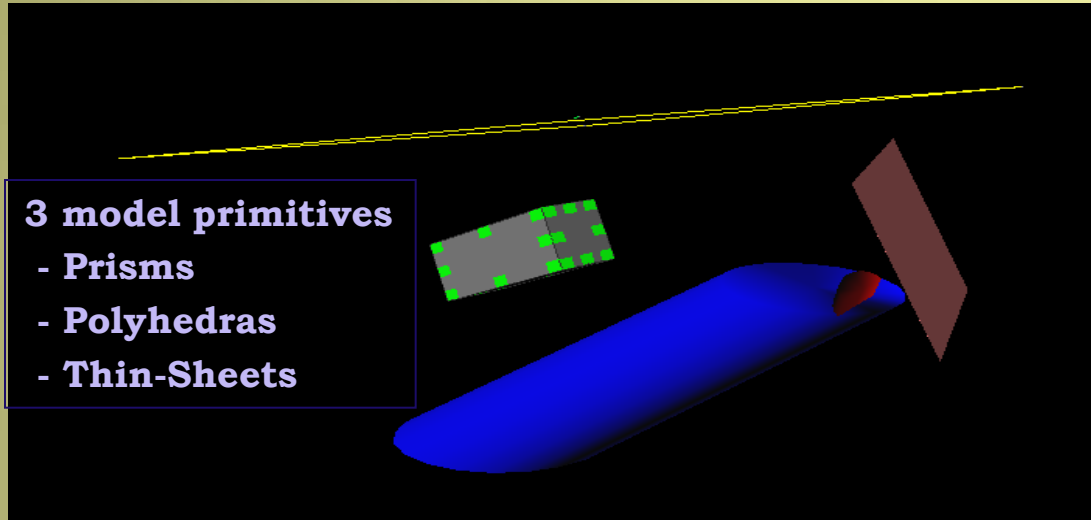
A fully integrated 3D visualization tool

Geological CAD Models

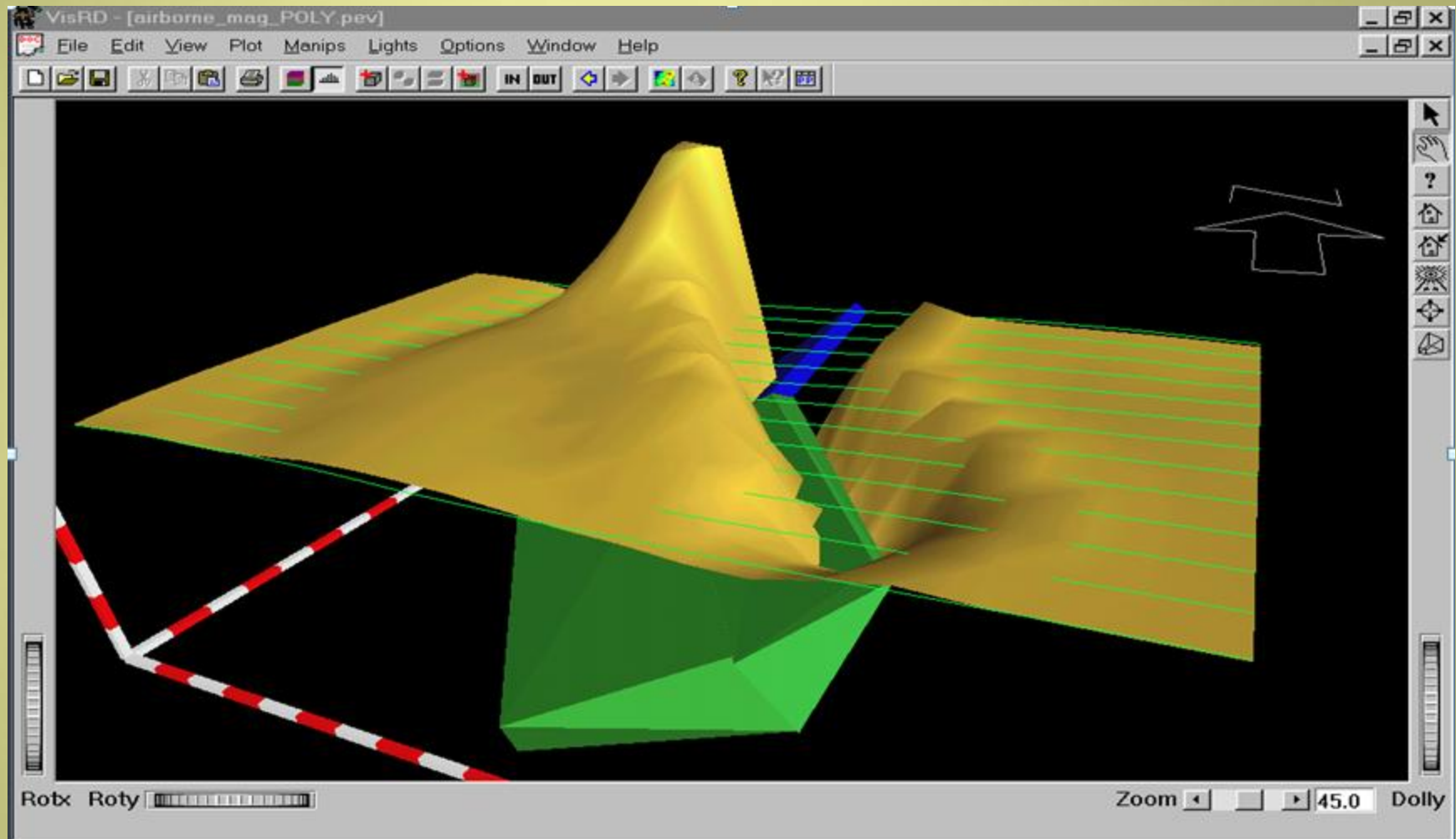


Complex 3D modelling capabilities including imports of geological models from CAD applications

3D Visual Model Building



Complex Structure and Data Visualization

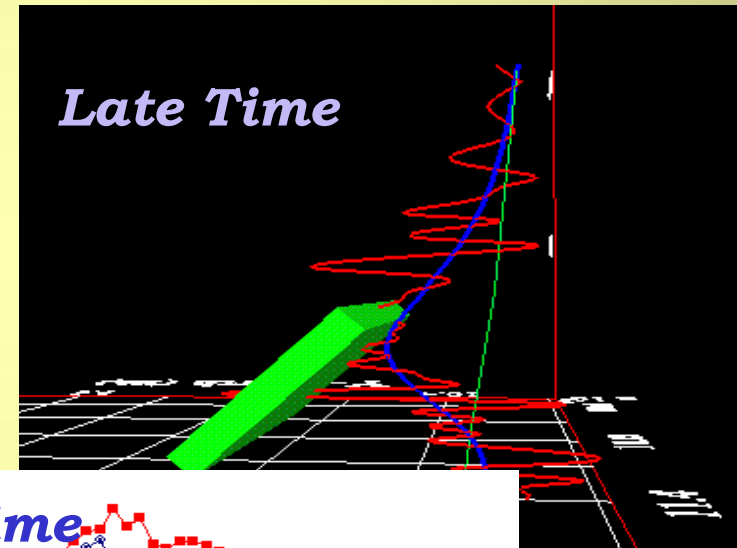
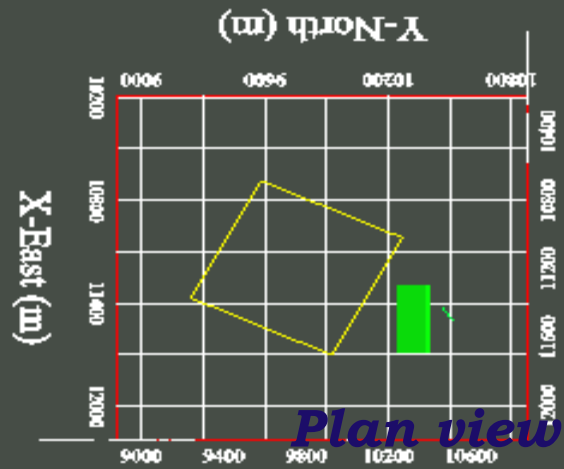


e.g. Airborne Magnetic Field Modelling

Simulation Calibrations

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

e.g TEM borehole response

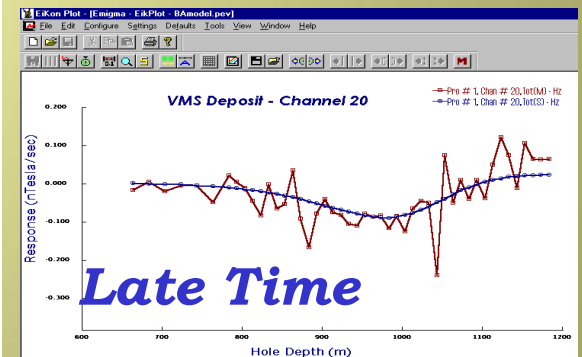
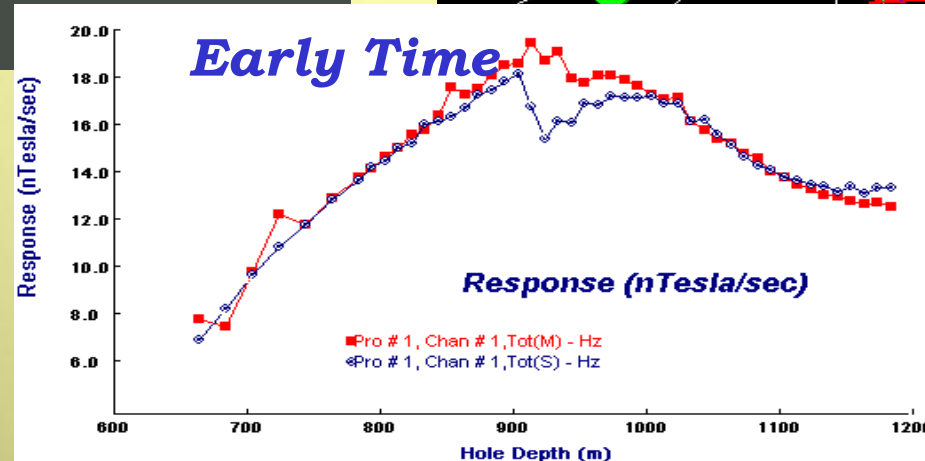
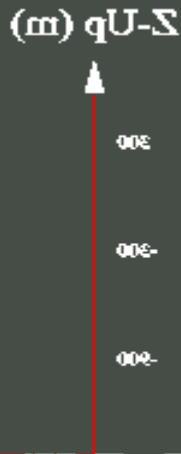


Blue line - simulated
Red line - field data

North view



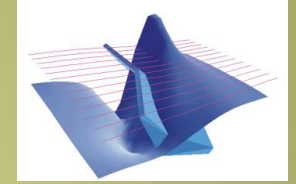
East view



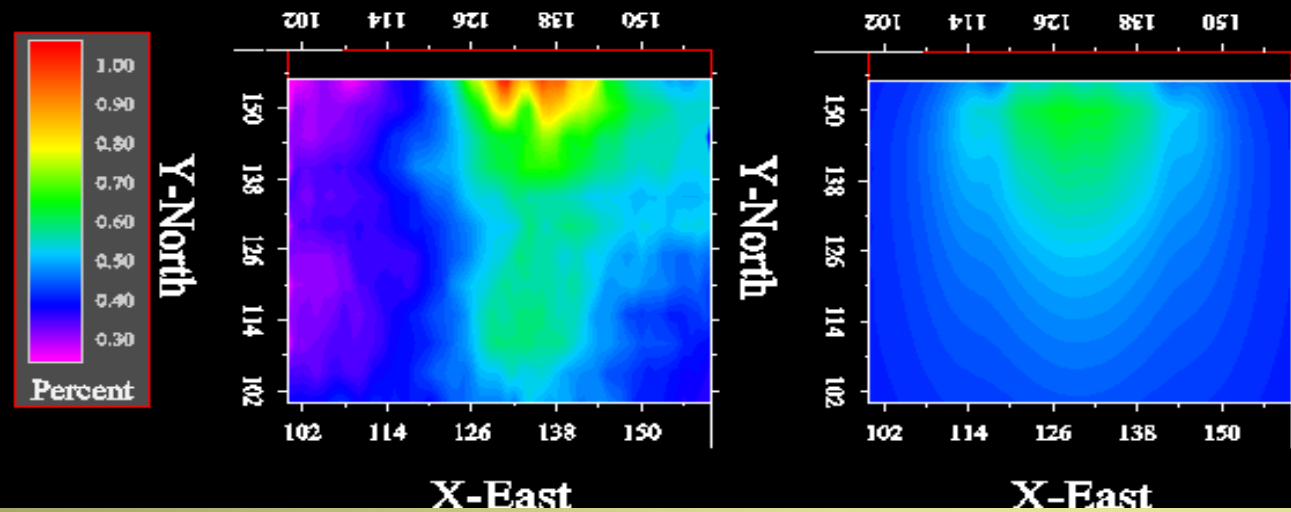
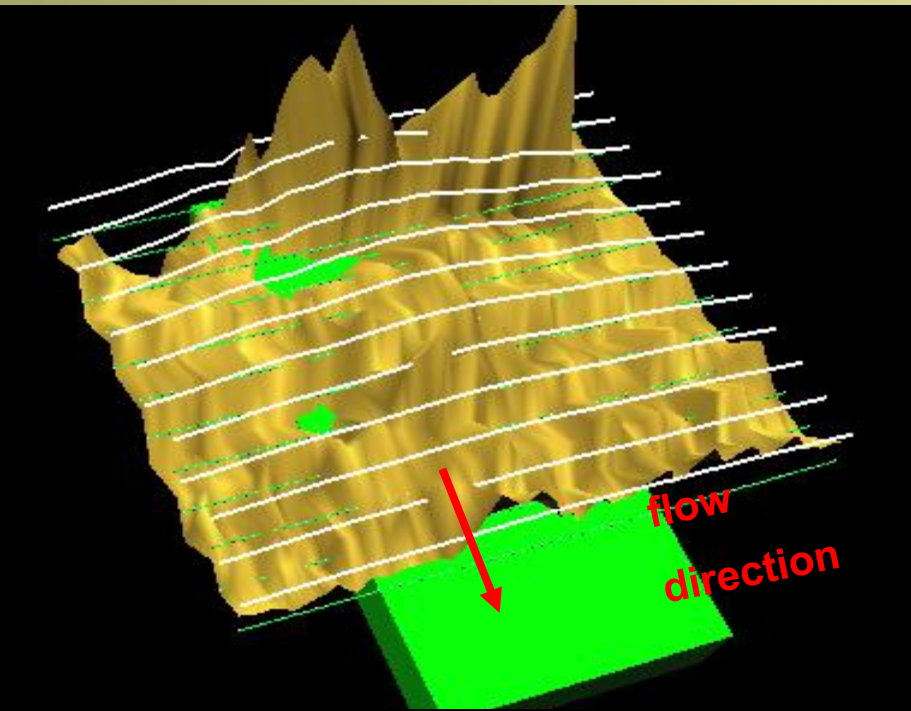
Model and Data Comparison

Contaminant Plume - EM31

Canadian landfill site

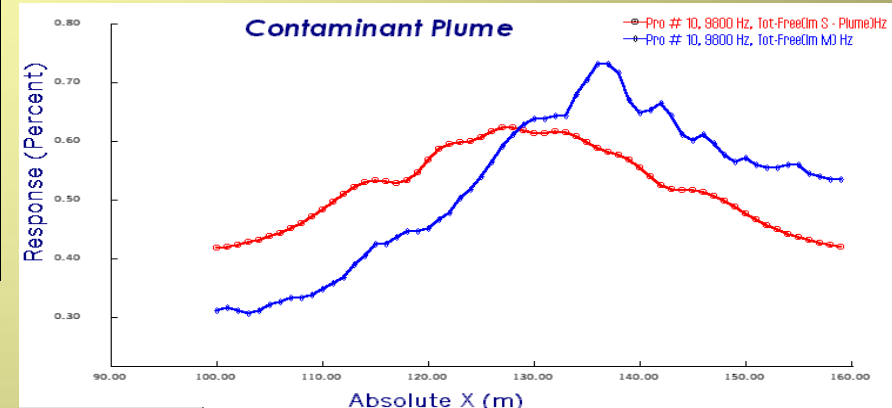


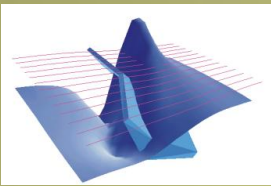
- ◆ 3D surfaces
- ◆ 2D contours
- ◆ 1D plots



Measured Plume Quadrature response

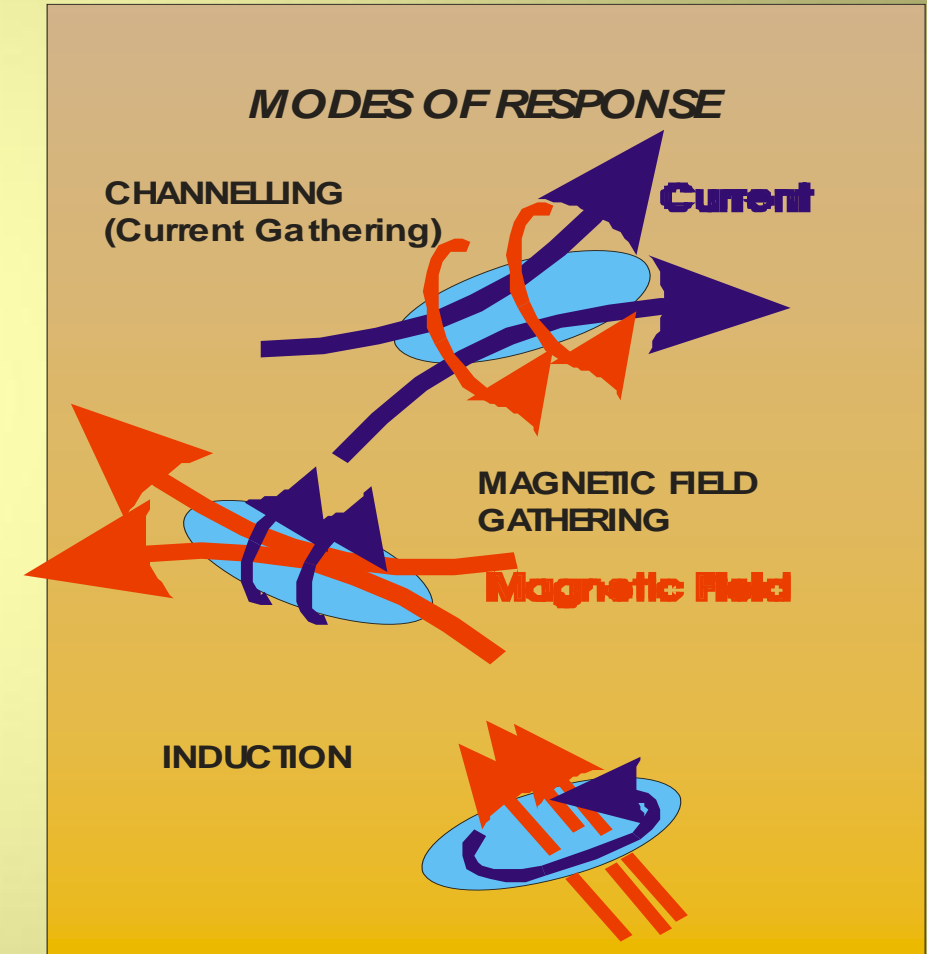
Simulated Plume Quadrature response





Geophysical Responses

- ◆ EMIGMA Algorithms
- ◆ LN (FEM,TEM,IP)
- ◆ EikPlate (FEM,TEM) in a conductive medium
- ◆ Eikplate (FEM,TEM) inductive layered solution
- ◆ ILN (FEM,TEM)
- ◆ MLN (Induced, Permanent)
- ◆ 3D Gravity (3 methods)
- ◆ Born techniques
- ◆ 3D Resistivity (fast, flexible, accurate)
- ◆ MMR ground and borehole



3D Modelling Capabilities 2

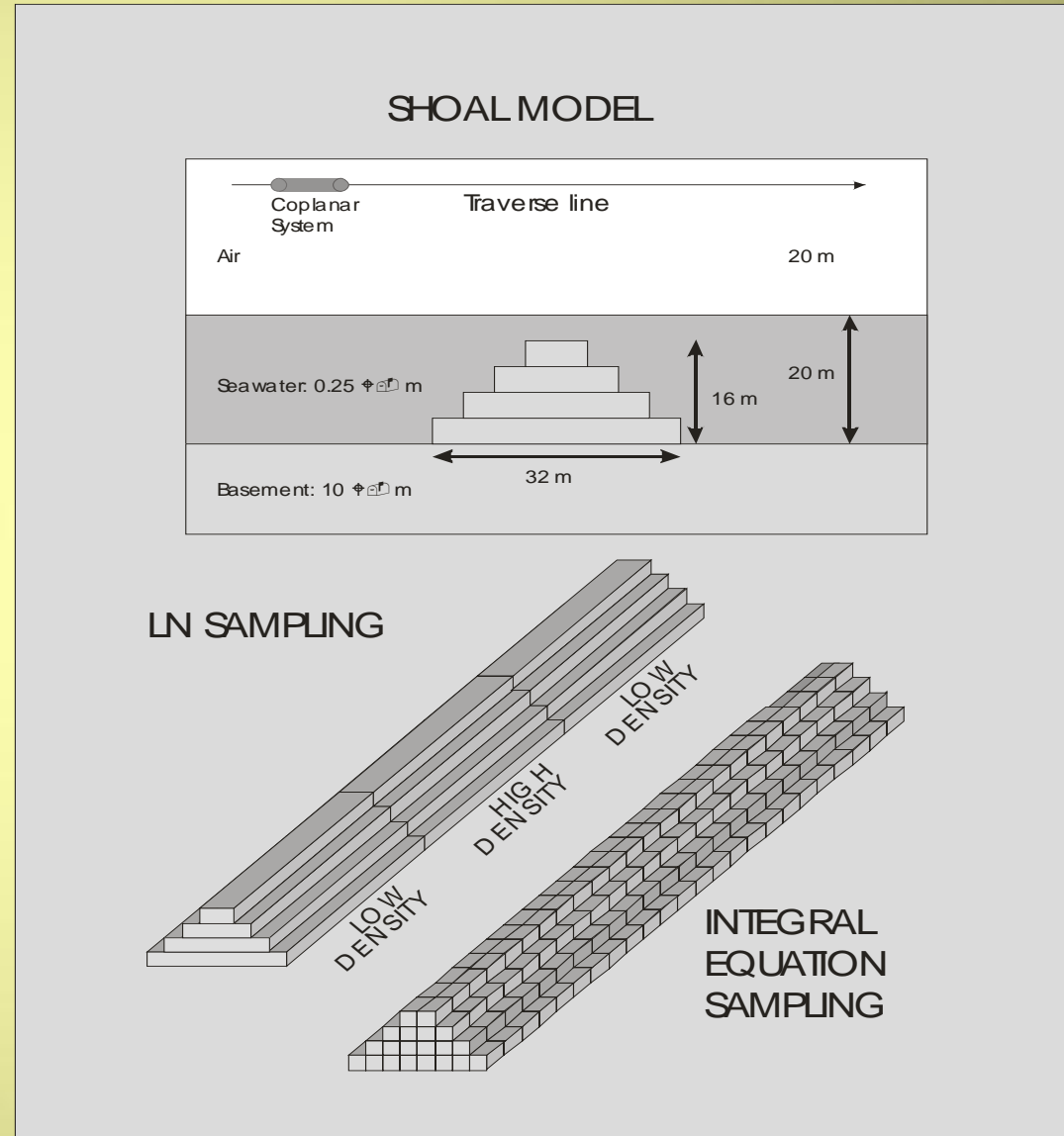
EMIGMA EM Algorithms

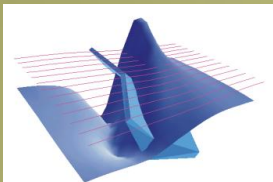
- ✓ LN
- ✓ EikPlate
- ✓ ILN
- ✓ MLN
- ✓ VHPlate
- ✓ FS (Free Space) plate

Rapid Convergence

Flexible and

Easy-to-Use Grids

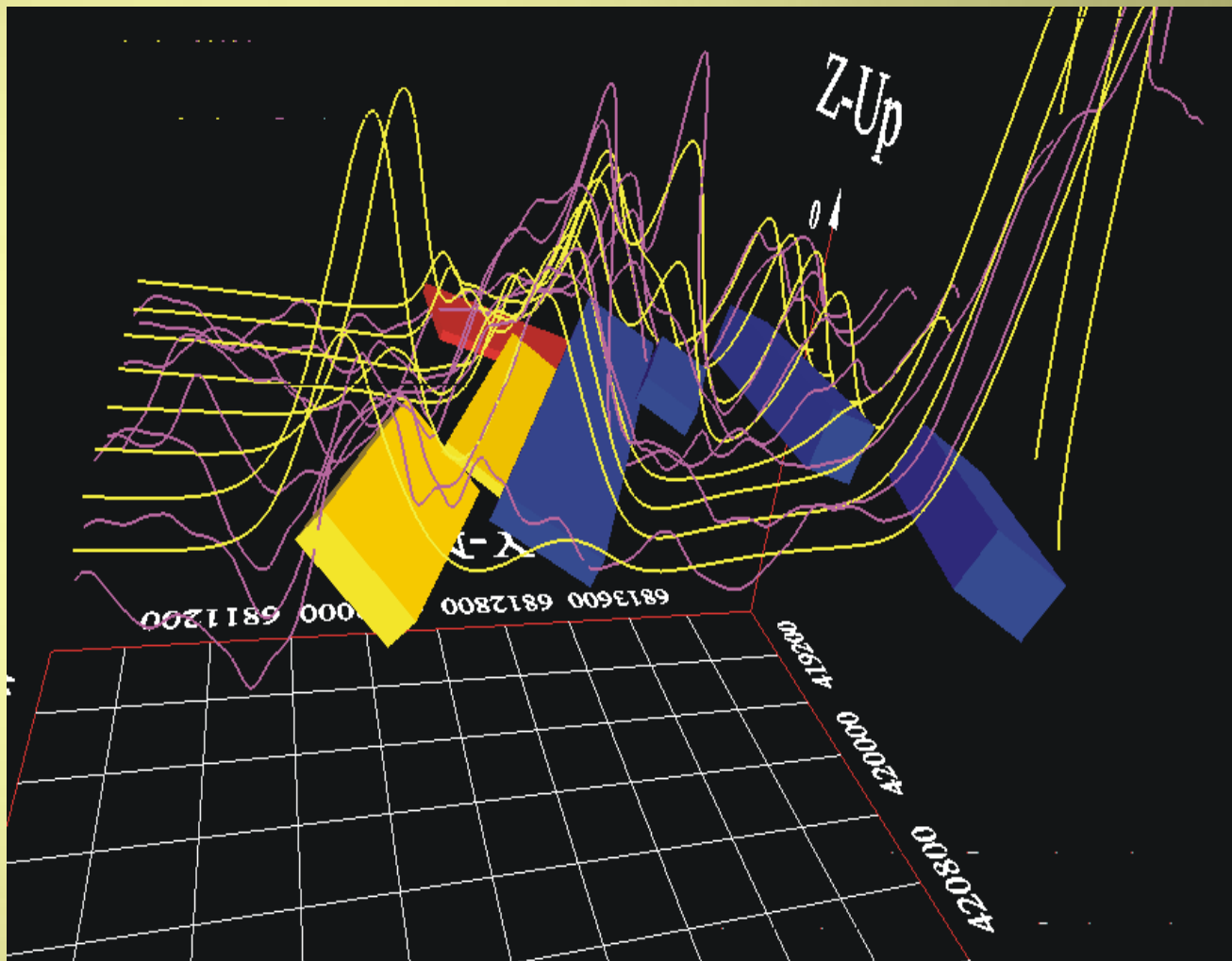


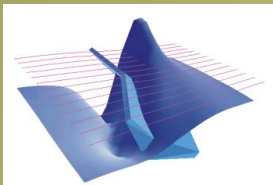


3D Modelling Capabilities 3 **Complex Models**

Full Range of Target Interactions

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

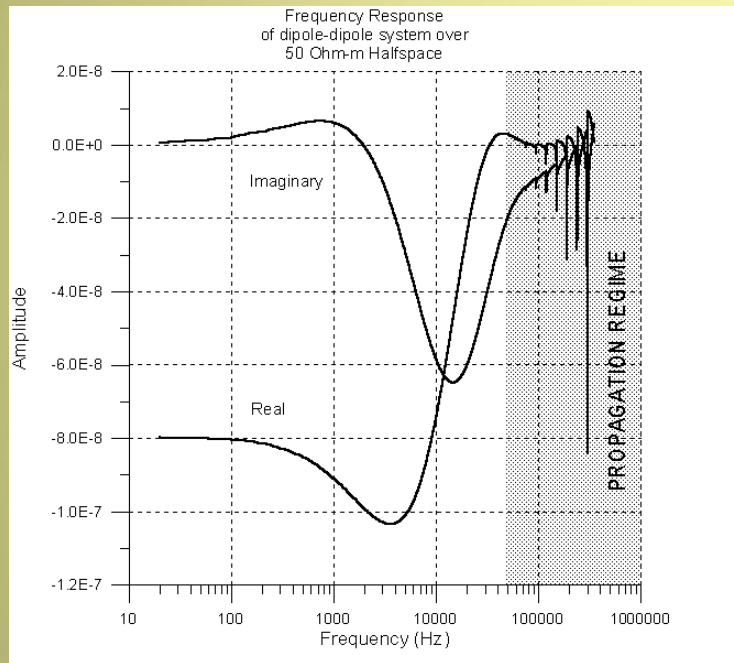




3D Modelling Capabilities 4

~Frequency to Time-Domain Transform

- ◆ Why
- ◆ How
- ◆ Waveforms
- ◆ Bandwidth



Typical Magnetic Response

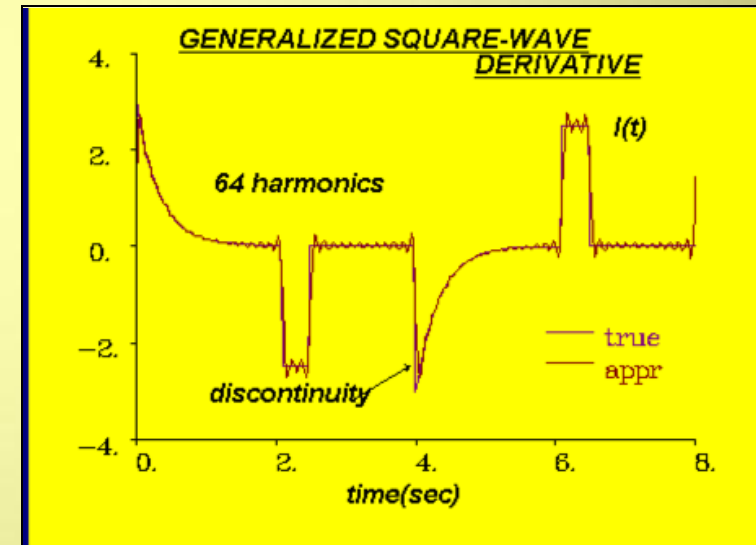
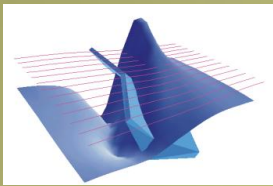


Figure 15: Fourier representation of derivative of the Generalized Square Wave using 64 harmonics.

Band limited Coil Response

Incredibly accurate transforms



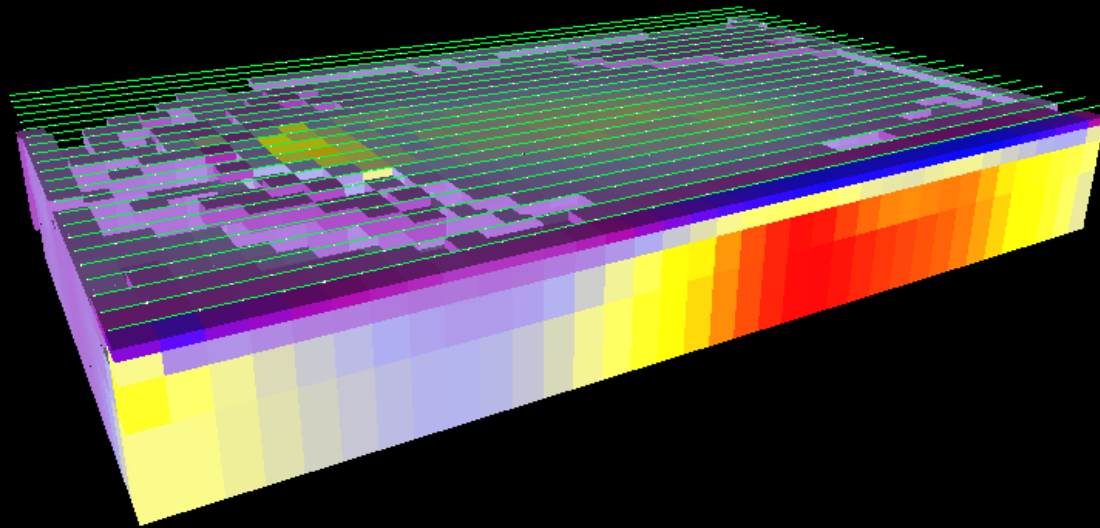
Inversion Capabilities 1

3D Magnetic field Inversion for Susceptibility

Sensitivity ✕

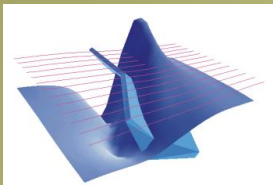
Minimum value

Maximum value



- ◆ **Multiple levels**
- ◆ **Gradients**
- ◆ **Components**
- ◆ **Matrix**
- ◆ **Optimization**
- ◆ **Linear/ Non-Linear**
- ◆ **Simulation Starting Models**
- ◆ **Strike rotated inversion grids**

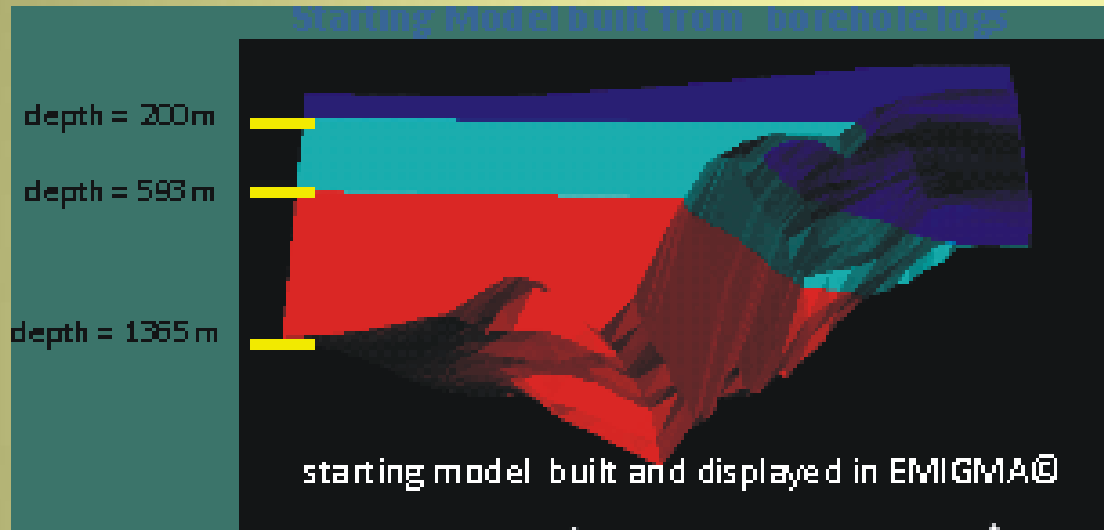
- **Magnetization Vector Inversions**
- **3D Euler plus statistical processing**



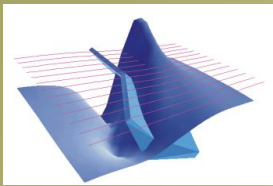
3D Gravity Inversion

Inversion Capabilities 2

- ◆ Utilization of topography
- ◆ Gradient capabilities
- ◆ use of horizon and drillhole constraints
- ◆ Extended Euler
- ◆ Fast inversions through new compile and multi-core processing



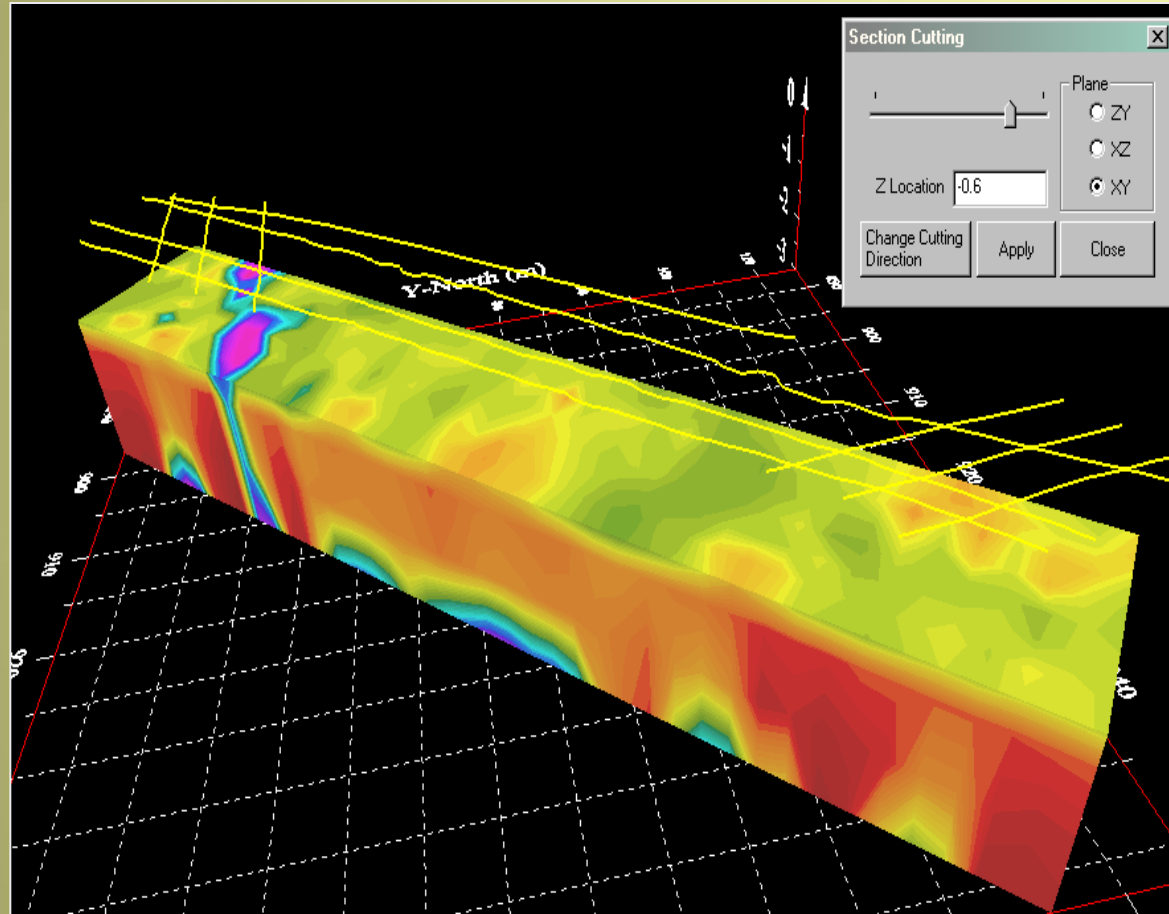
➤ 3D Euler plus statistical processing



Inversion Capabilities 3

1D Inversion

TEM, FEM and Resistivity



FEM

**- ground , HEM, fixed-wing
joint resistivity and
susceptibility**

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

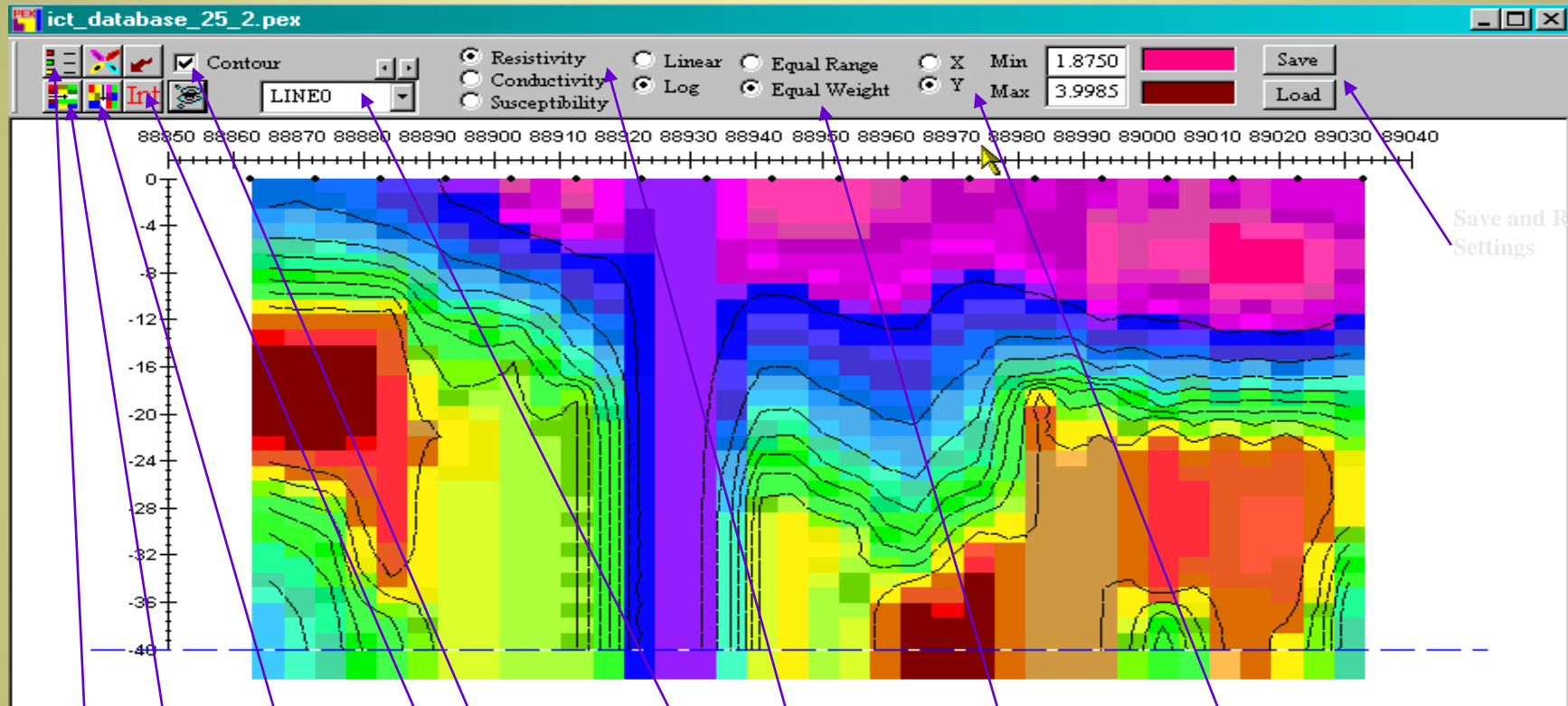
Resistivity: 1D/3D Inversion

**Sengpiel Sections:
HEM, Fixed-Wing**

**FEM, TEM Apparent Resistivity
HEM and Ground**

Inversion Capabilities 4

PEX- file Viewer



Legend

2D Interpolation

ModelUnits

Horizontal Axis selection

Interpolate Vertically

Apply Contour

Select Line

Colour Distribution

Equal Range – intervals equal

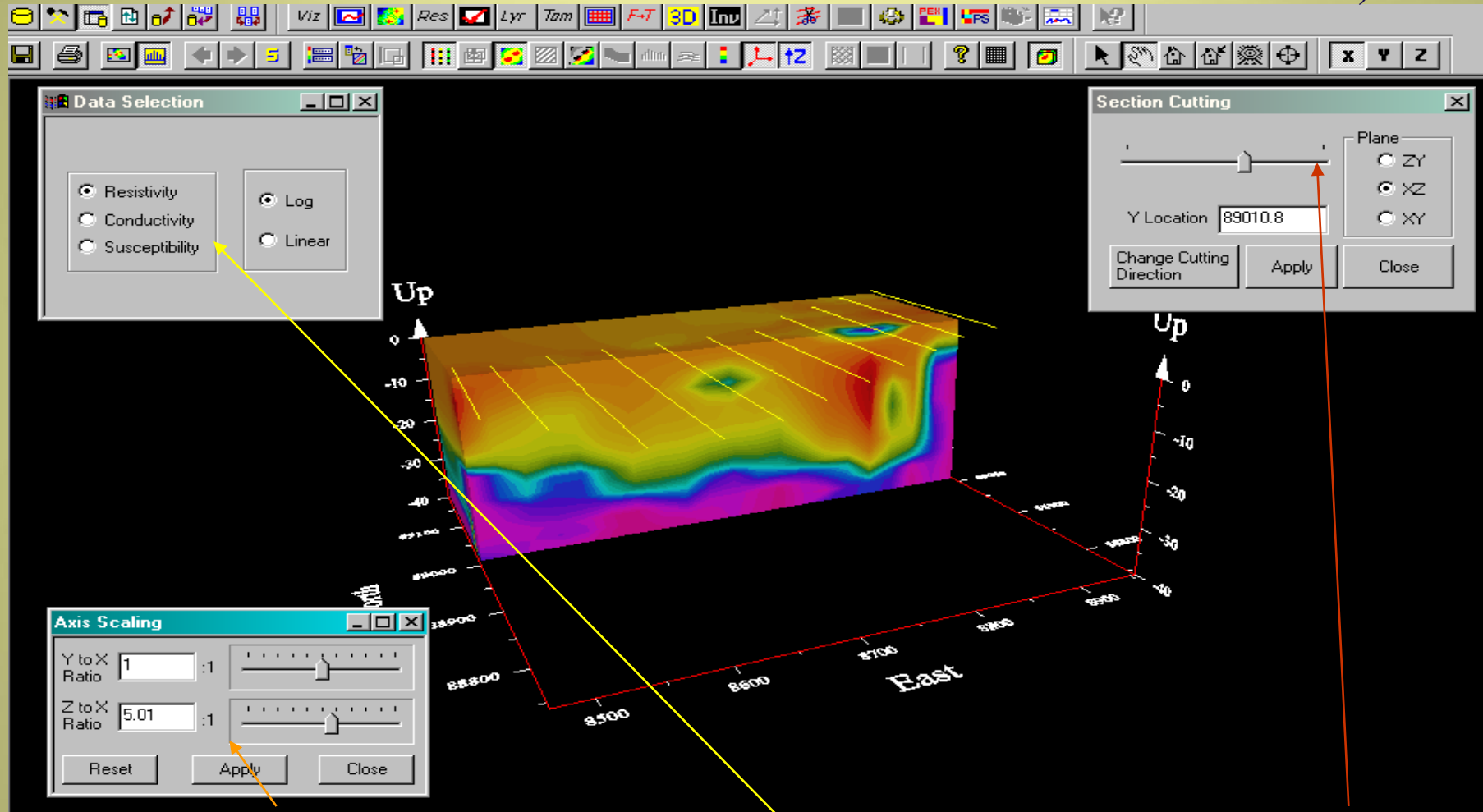
Equal Weight – distribution equal

Interpolate Horizontally

Save and Retrieve Plot Settings

Inversion Capabilities 5

3D Volume Contour
(with Inversion model
dataset selected)

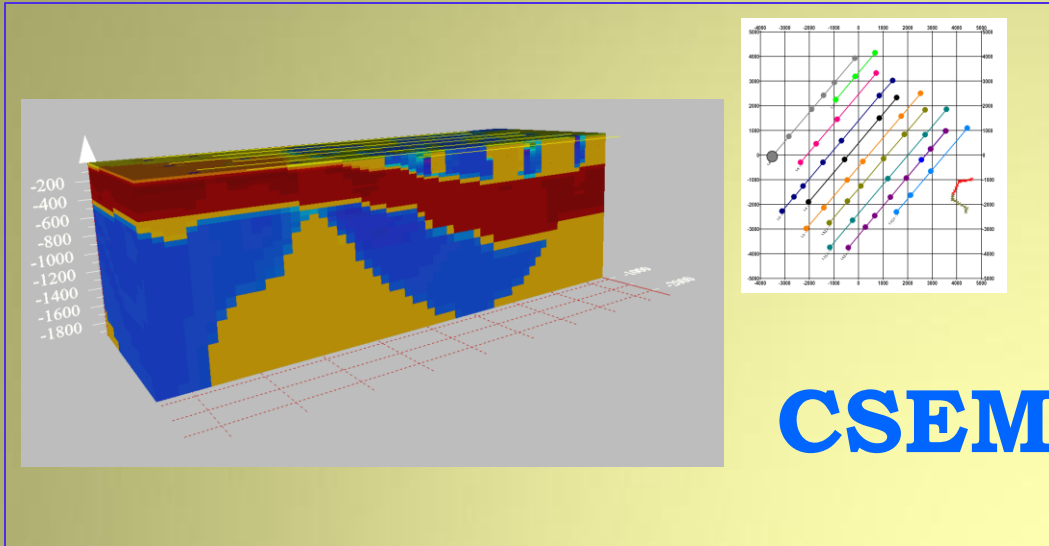


Axis Scaling

Model Units

Section Cutting

Inversion Capabilities 5



3D Inversion

Gravity and Magnetics

Resistivity

MT and CSAMT

CSEM – land based

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 and pole-pole surveys

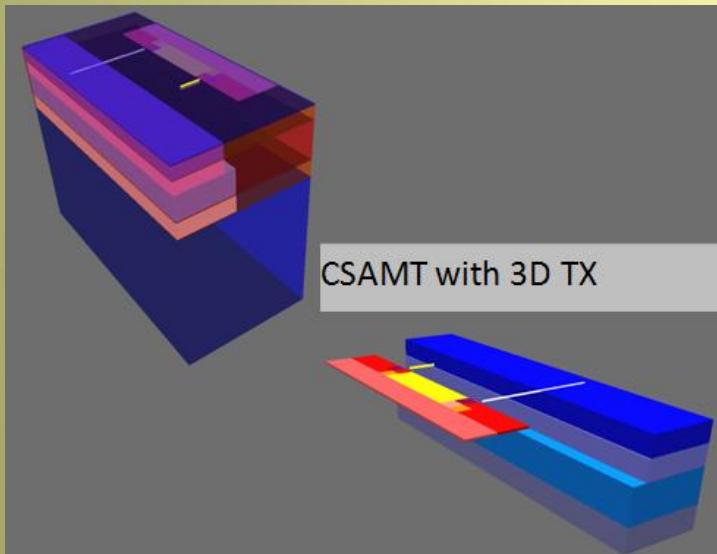
-resistivity constraints and user-specified starting model

MT

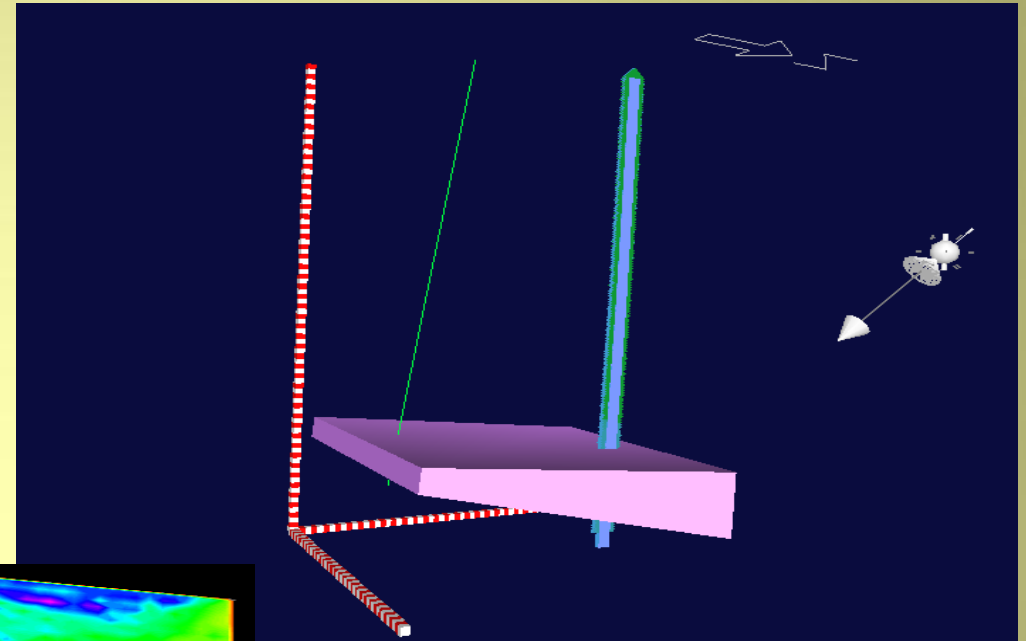
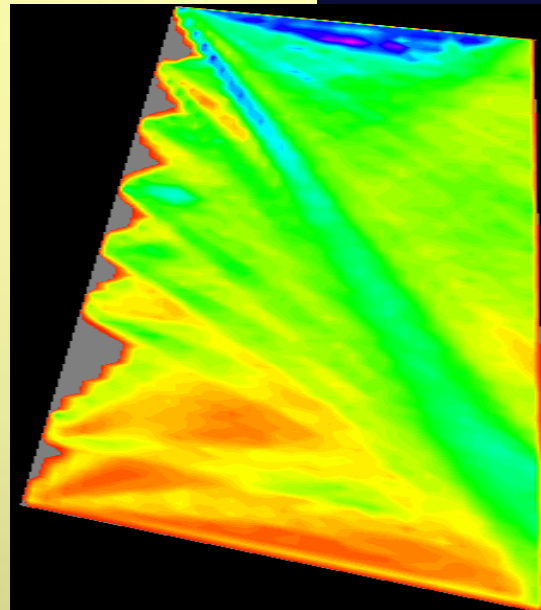
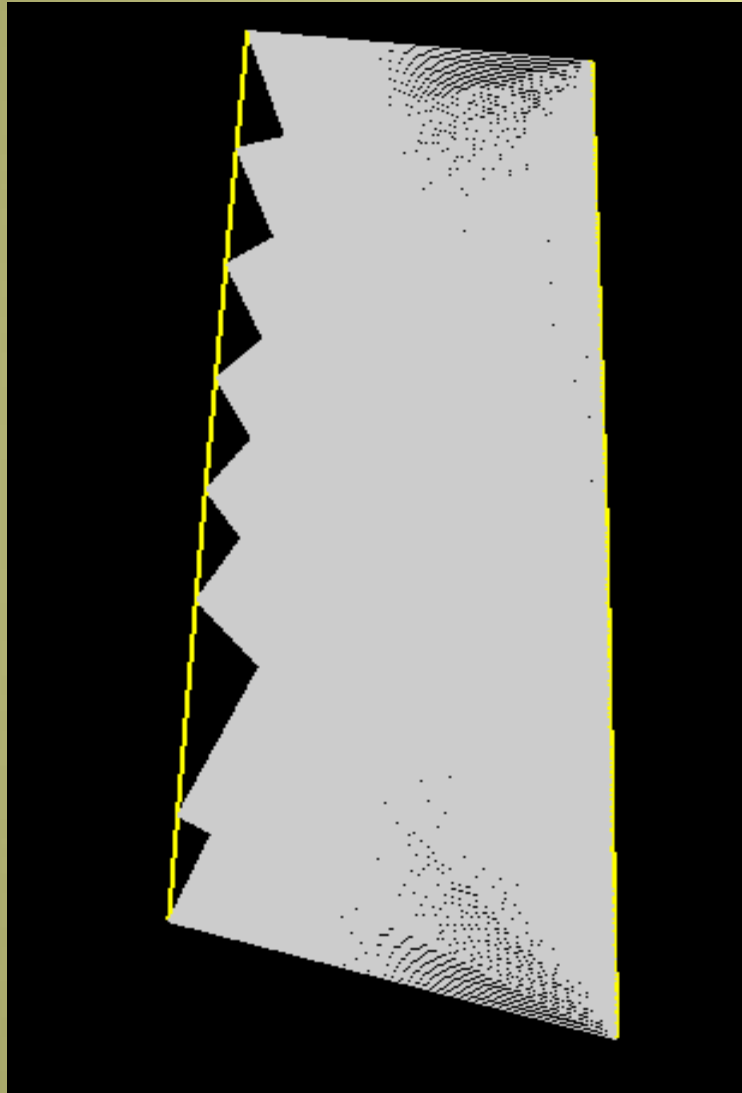
-3D inversion (with post-inversion removal of grid cells)

CSAMT

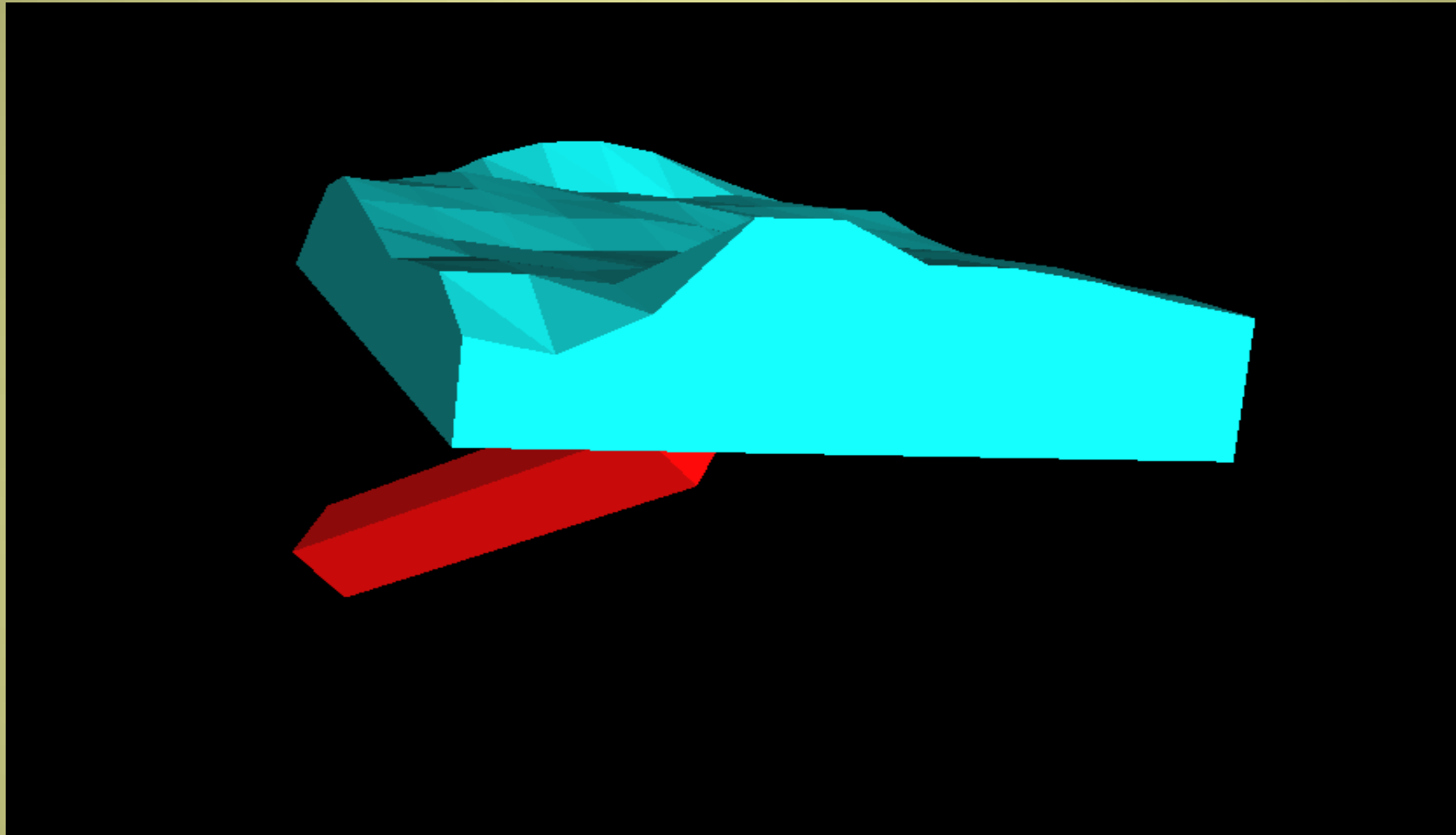
-accurate 3D inversion (utilizing source geometry)



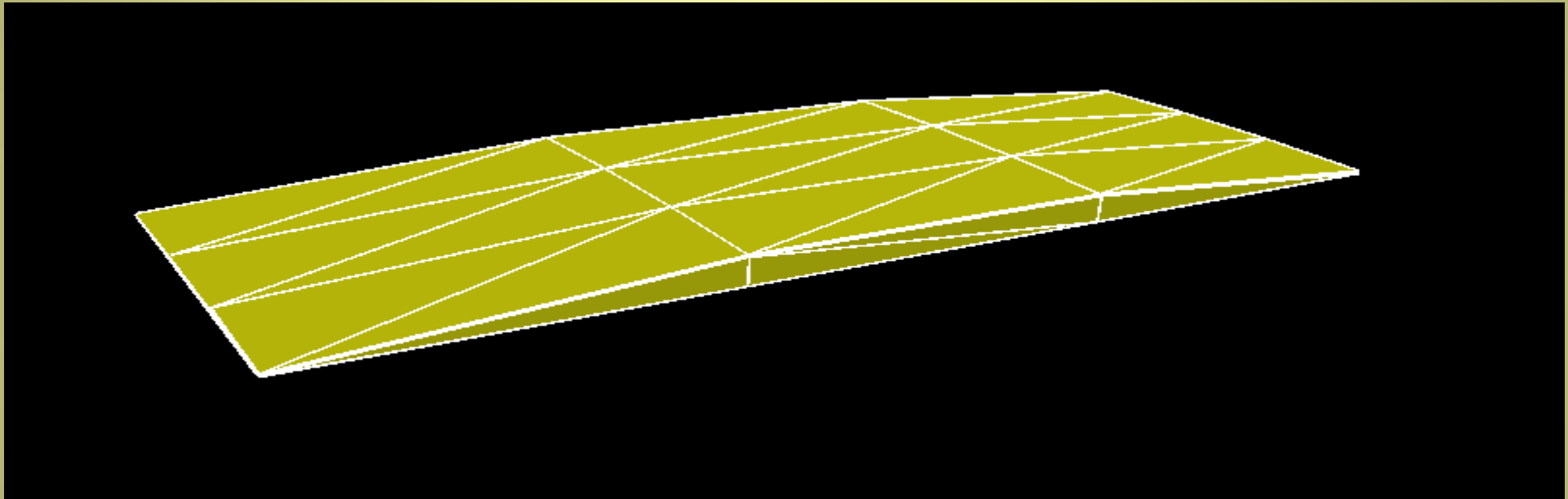
Crosshole Applications



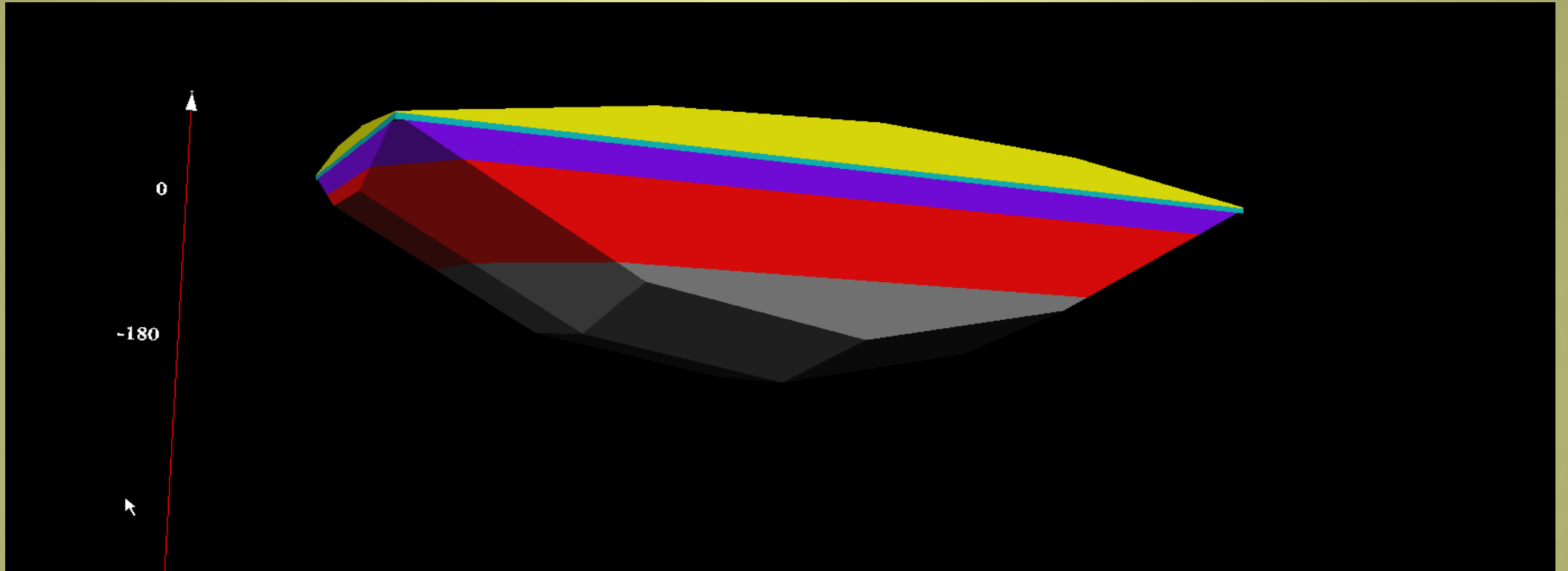
RIM data – lead mine



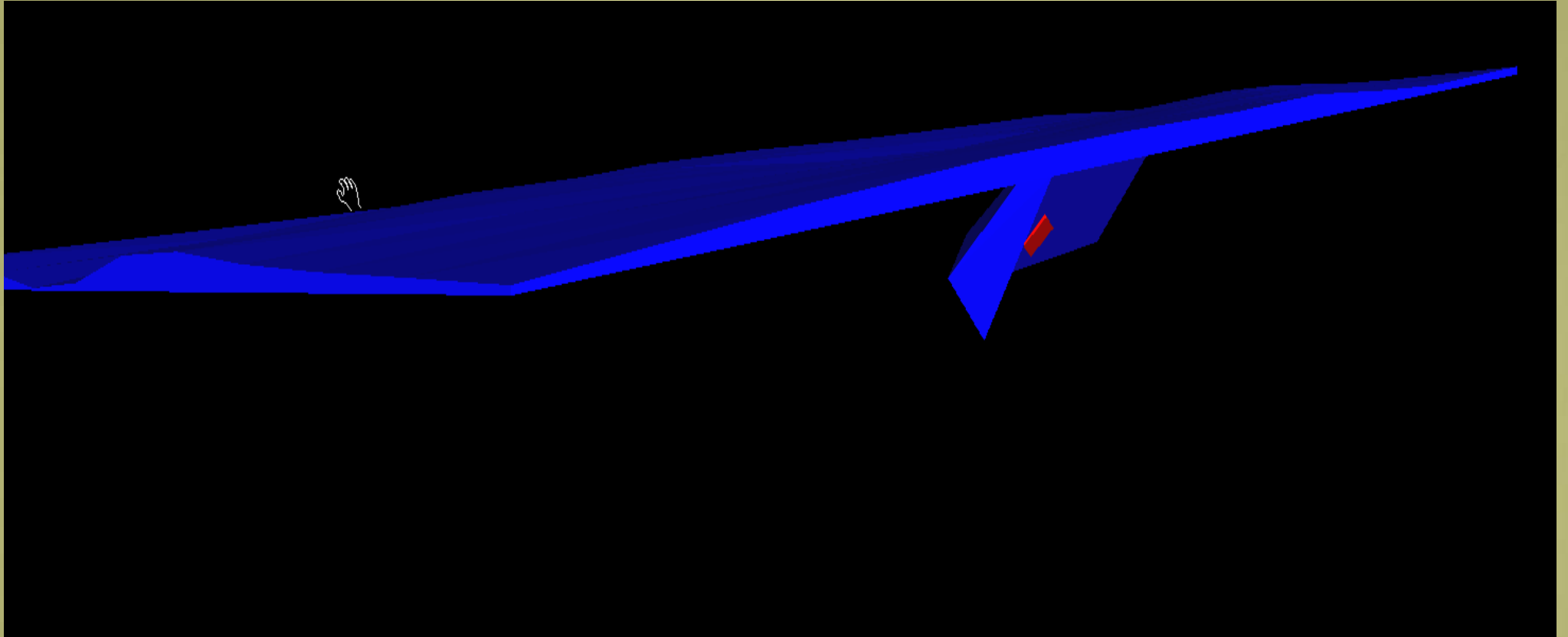
◆ **Topography plus Anomaly – MT project**



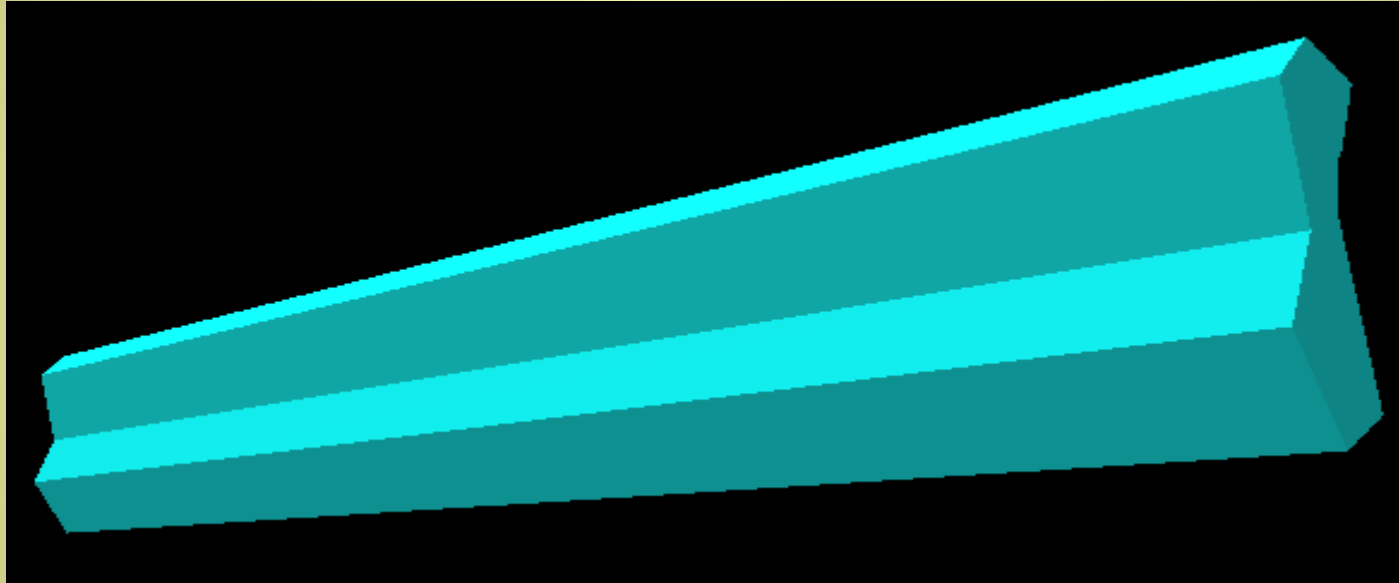
◆ **Anticline – MT plus gravity project**



◆ **Waste Dump Modeling: EM, gravity, IP, magnetics**



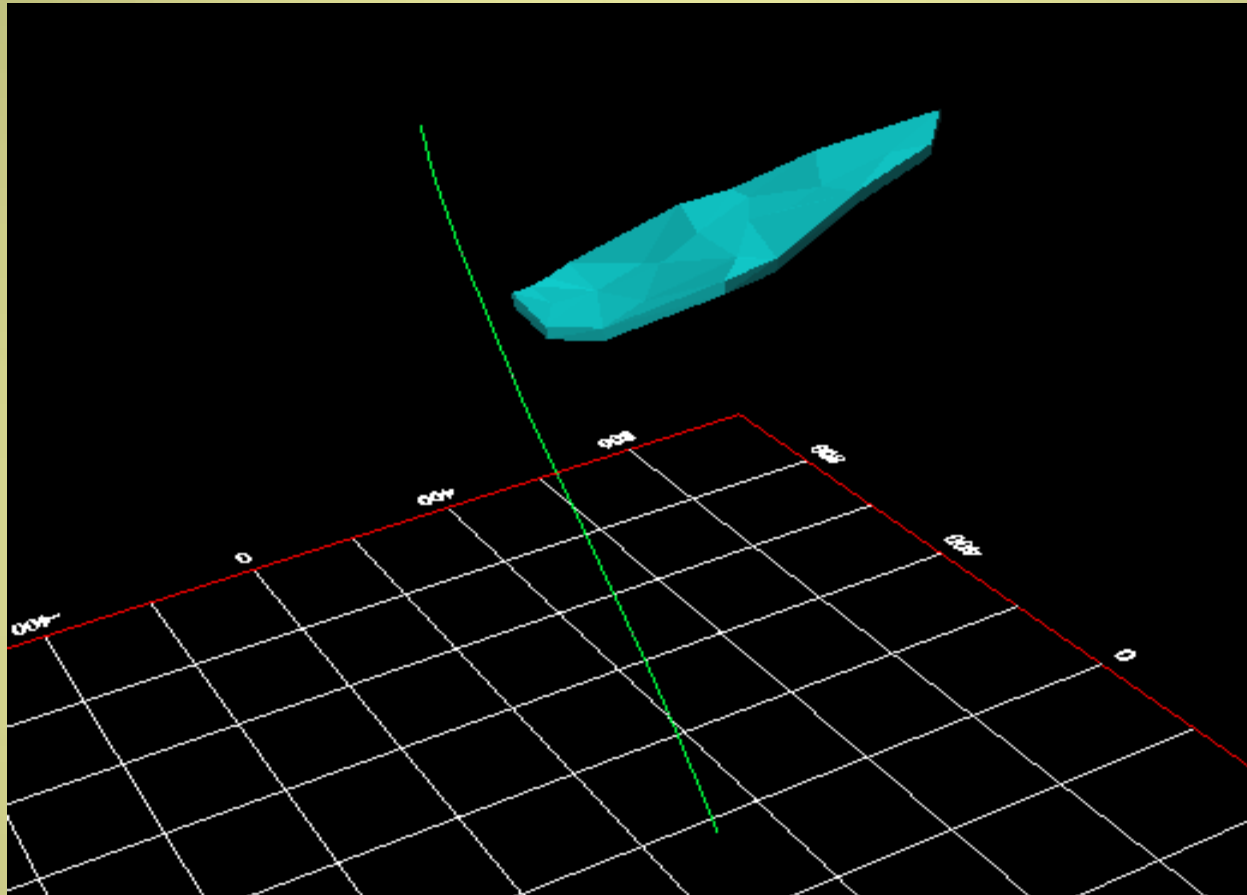
- ◆ **Magnetic Intrusions plus Topography plus Target**
- ◆ **Airborne magnetics and EM**



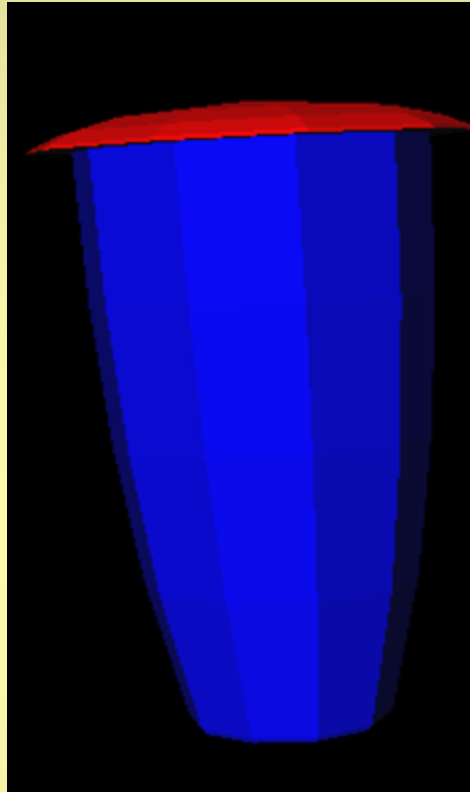
- ◆ **TEM Conductor:**
Copper – Nickel project



Copper-Nickel Resource: Magnetics, Gravity, EM



◆ **Massive Sulphide Deposit – Borehole TEM plus Magnetics**



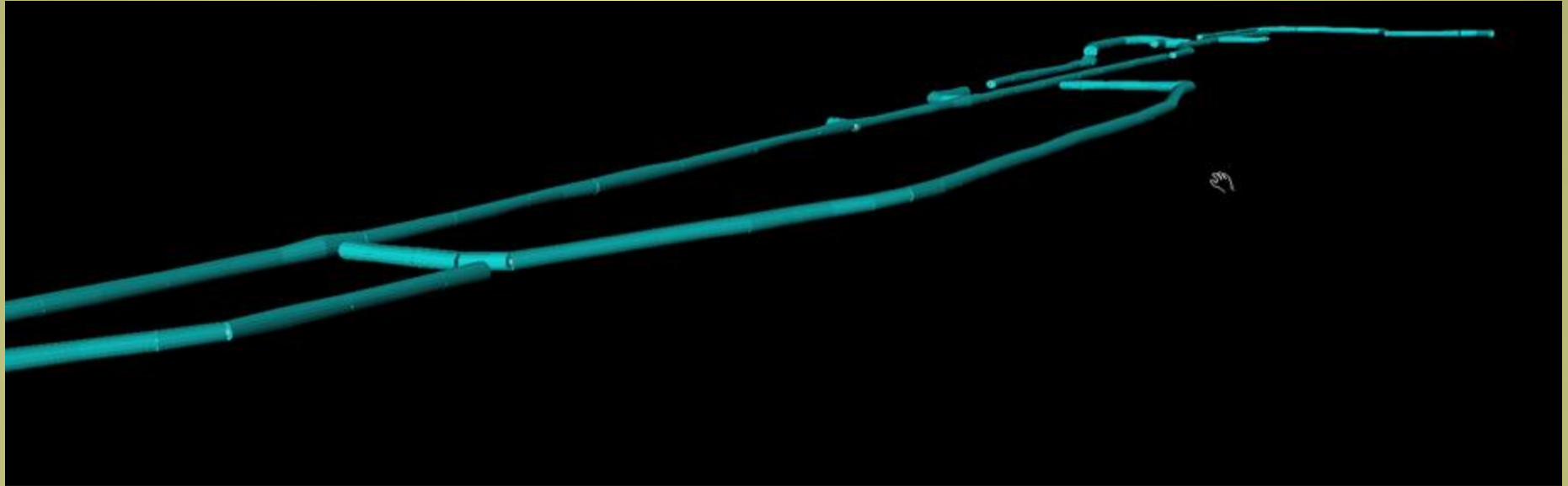
◆ **Classic Salt Dome Model - Gravity**



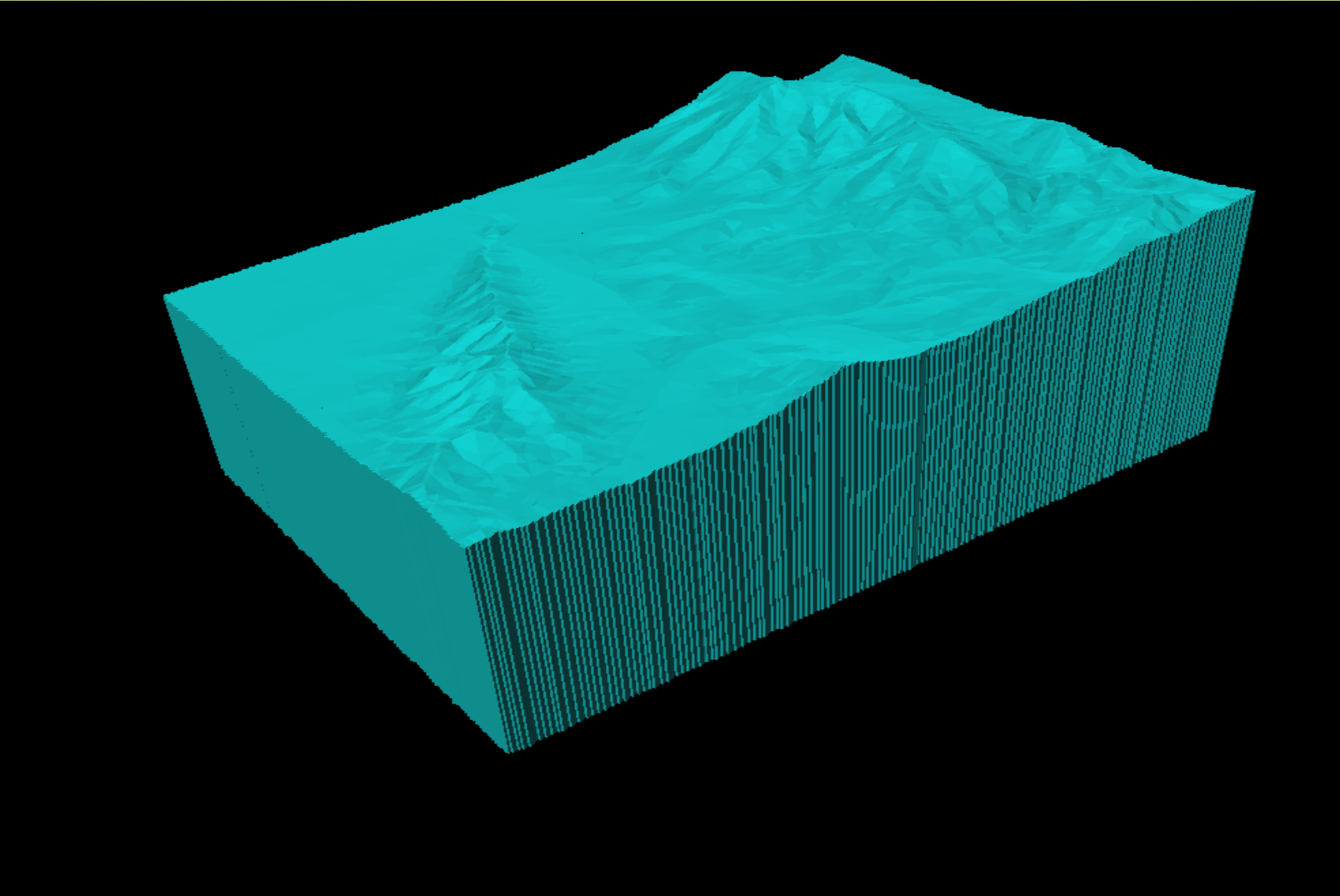
◆ **Steel Utility Pipe - towed FEM ground array**



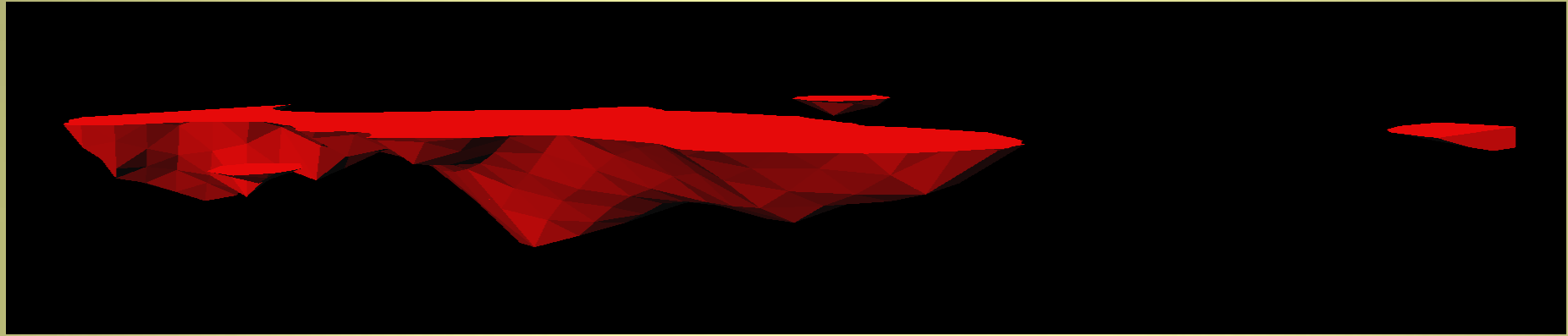
◆ **Gold Resource - IP, Gravity and Magnetics**



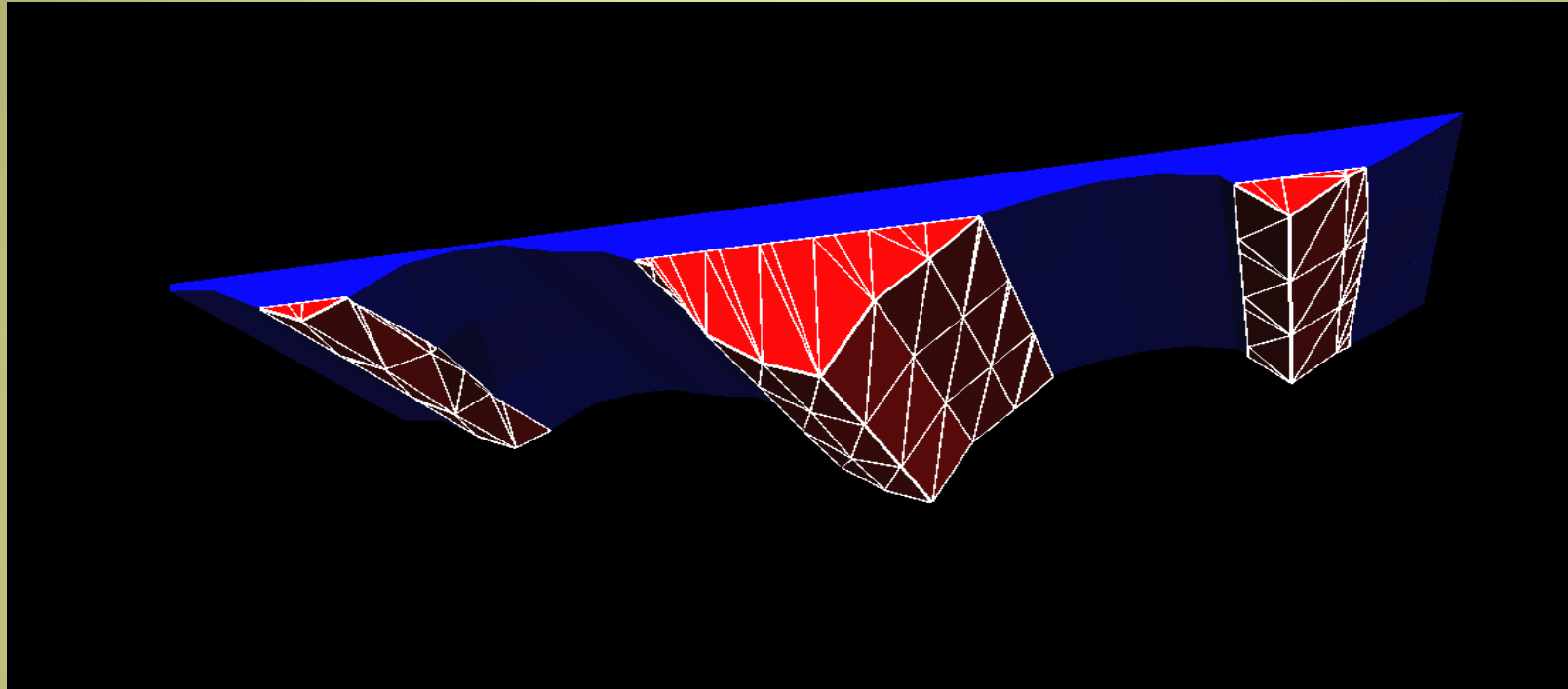
- ◆ **Underground Mine Workings:**
- ◆ **Borehole, Ground and airborne gravity**



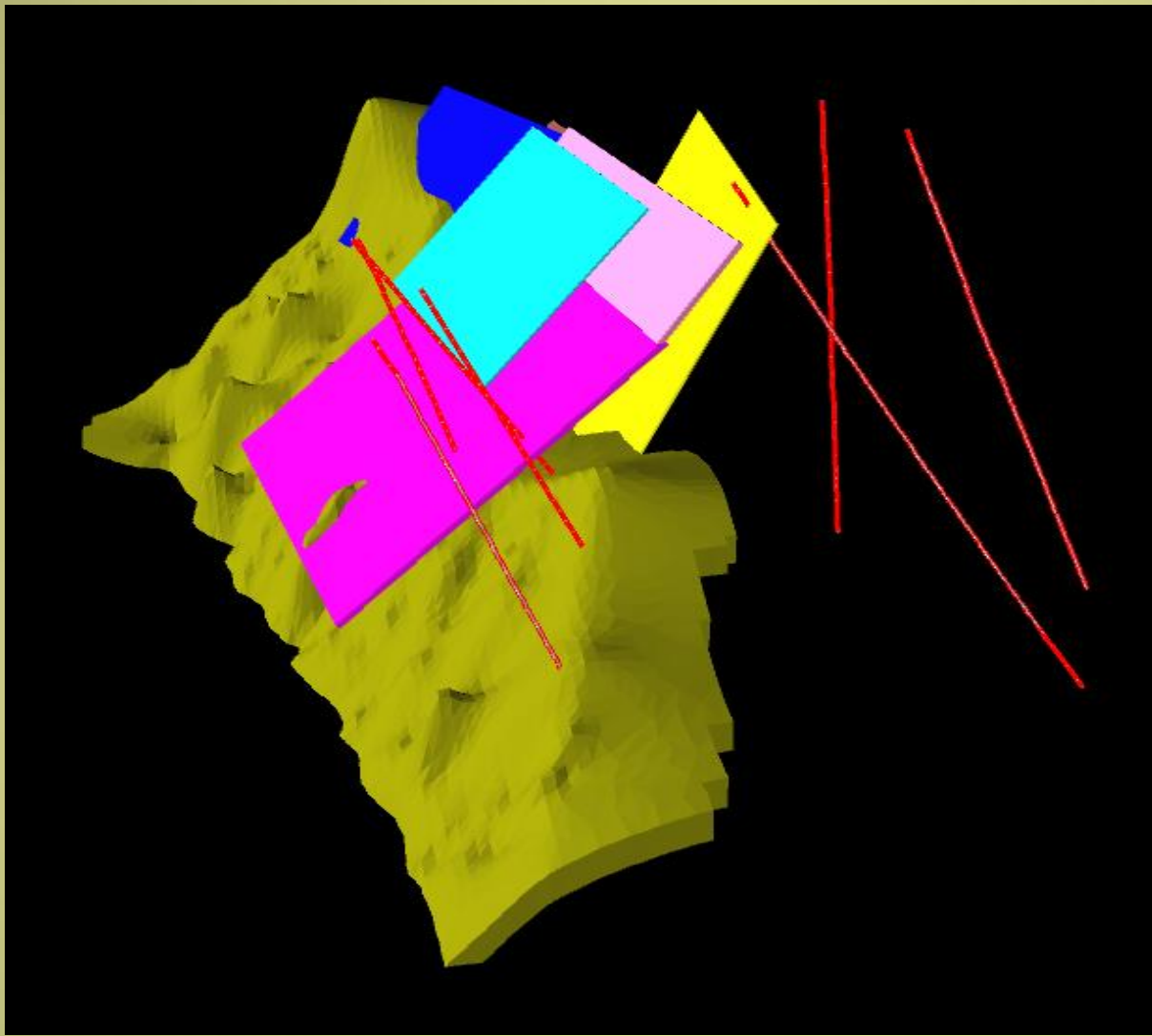
◆ **Complex Topography Model: Gravity**



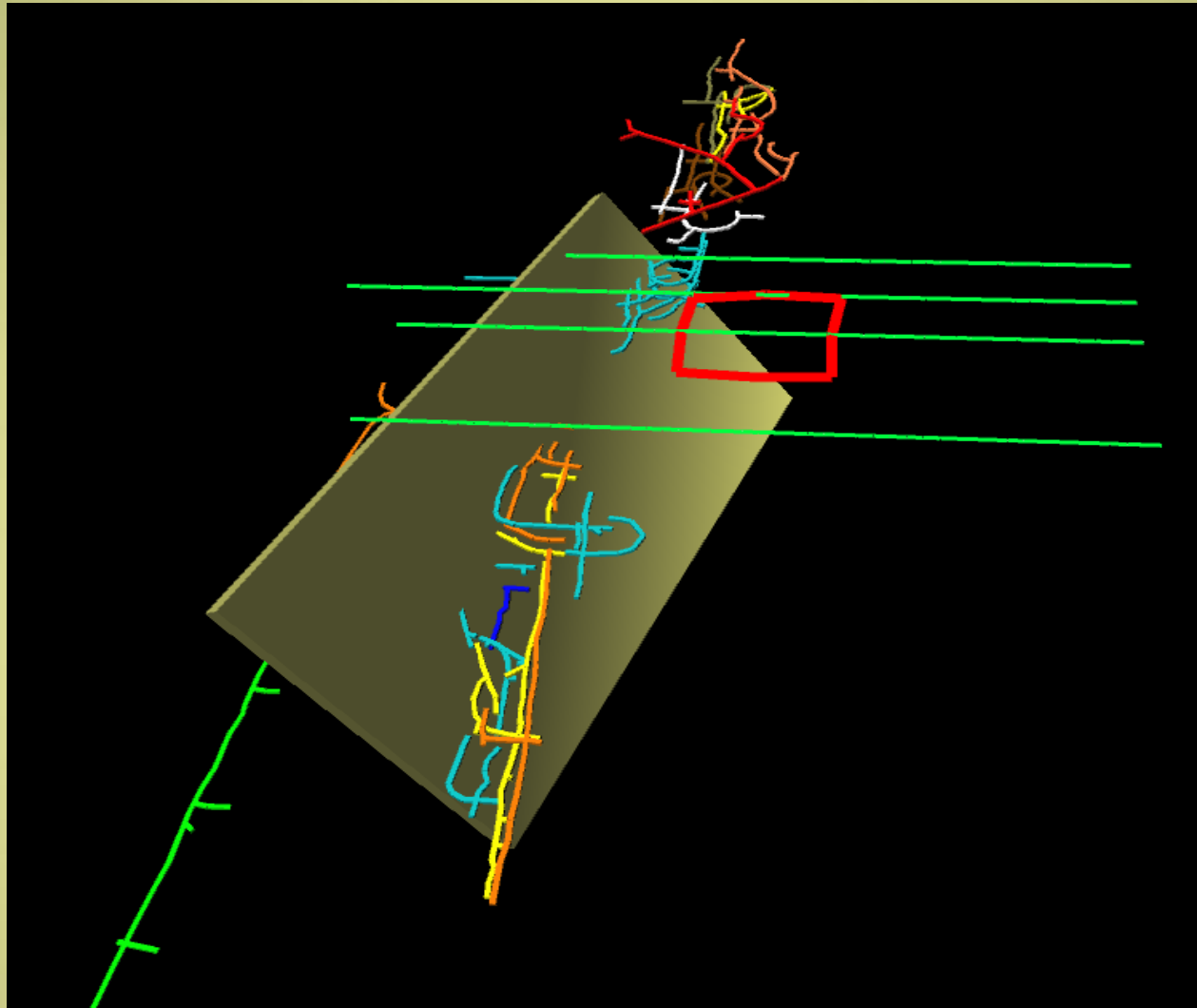
◆ **Basin Model: Gravity**



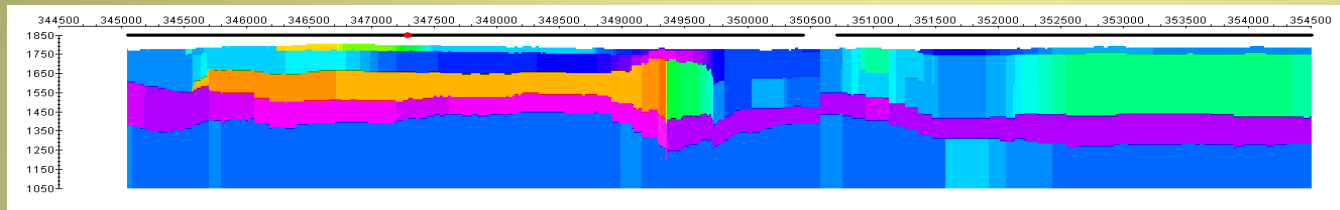
◆ **Aquifers Model: Ground Gravity and Airborne TEM**



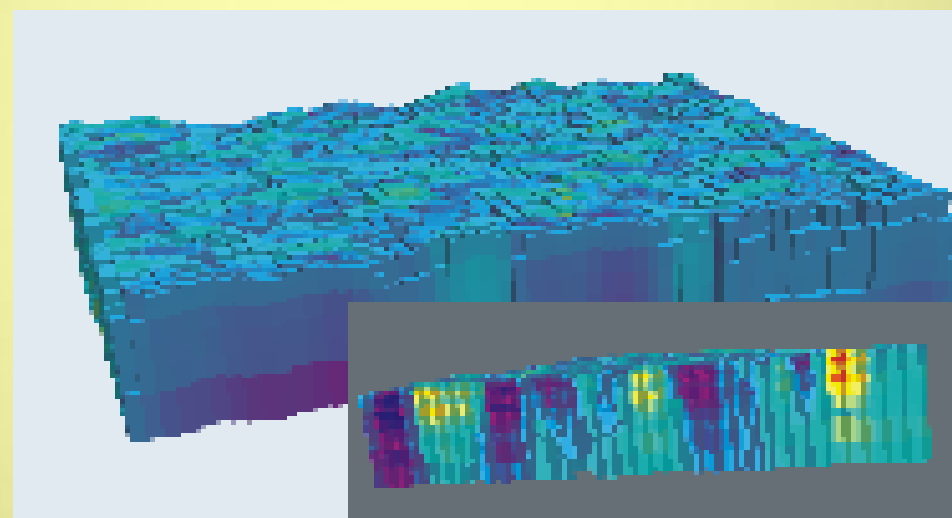
◆ Ore bearing zone, new TEM targets, boreholes



**Ground TEM modeling in conjunction
with underground workings**



Airborne TEM Inversion



AeroGravity Inversion

EMIGMA Training Tools



- **Manual in Text and Digital Form !**
- *describes all the basic concepts*

- *HELP – embedded within product*

- **Movie Tutorials**
- **extensive examples**

- **Tutorials in .ppt and .doc formats**
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