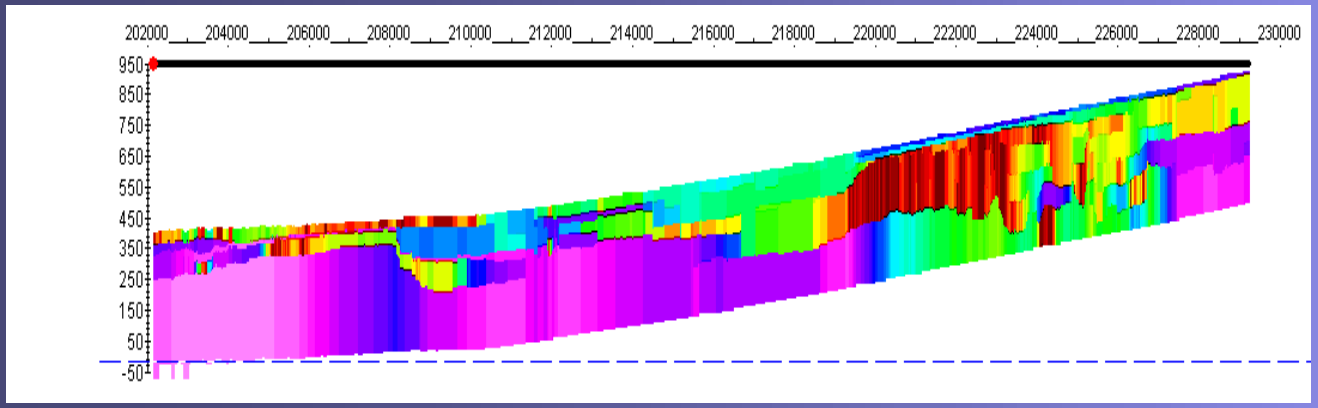
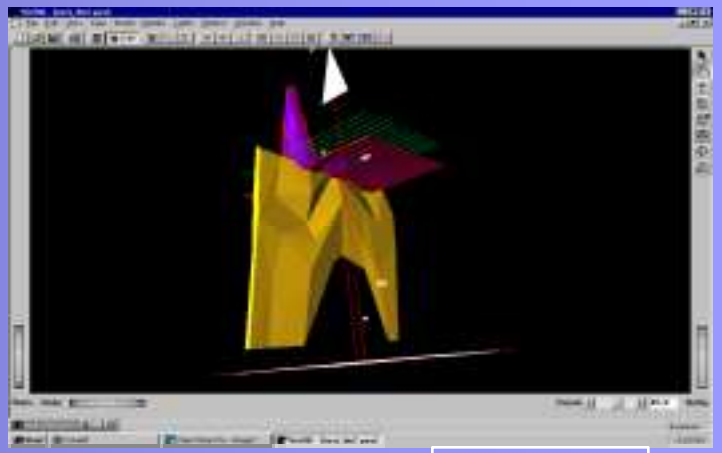
PetrosEikon (Earth Imaging)

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

Aquifer study

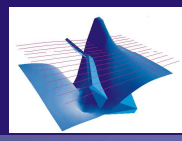


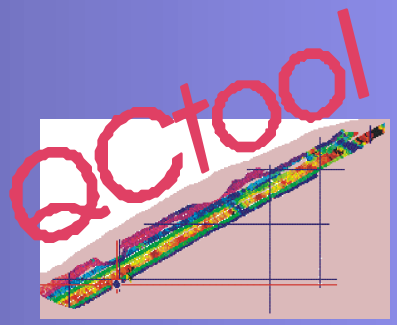


Ni/Zn Deposit

EMIGMA V6.1

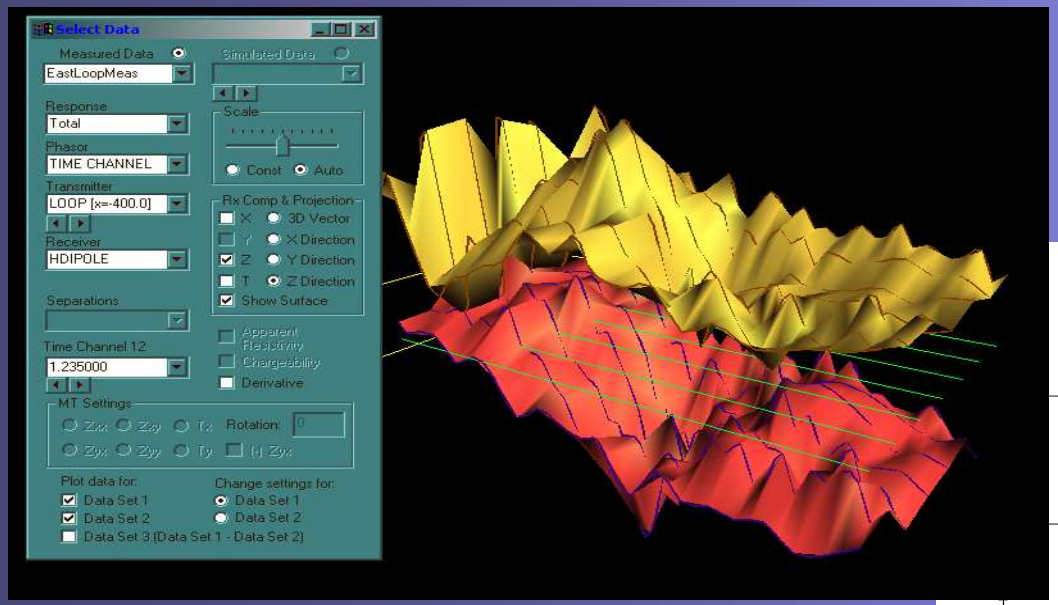
Sophisticated software for the practicing Geoscientist





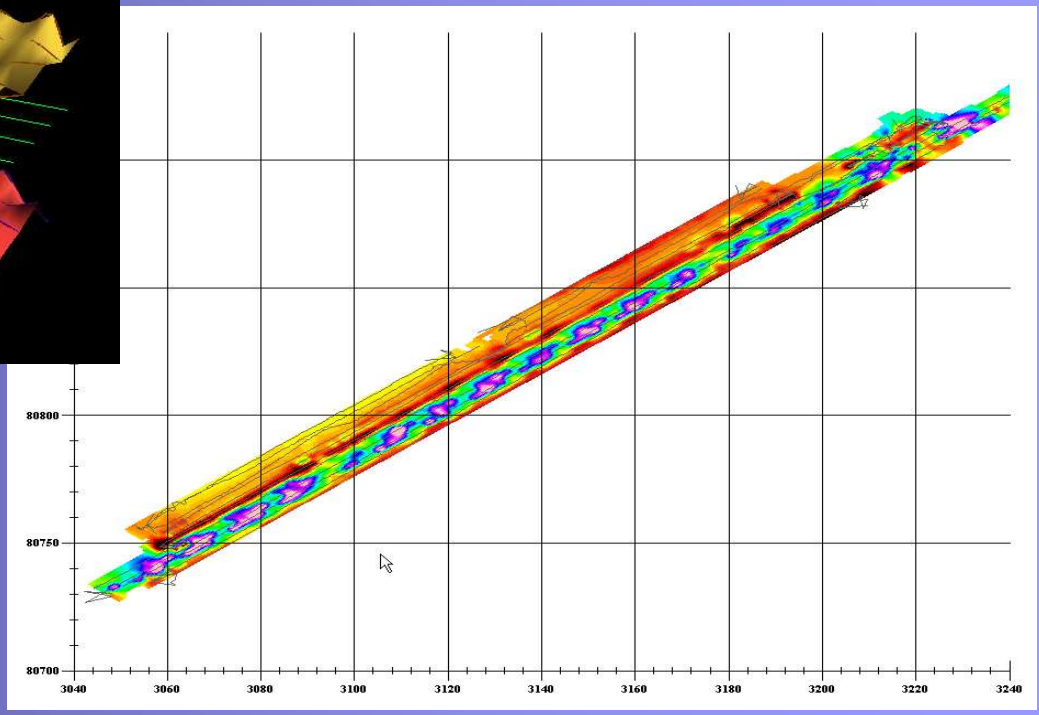
GEOTUTOR

Since 1994, Developers of Software for Interpretation of Geophysical Data



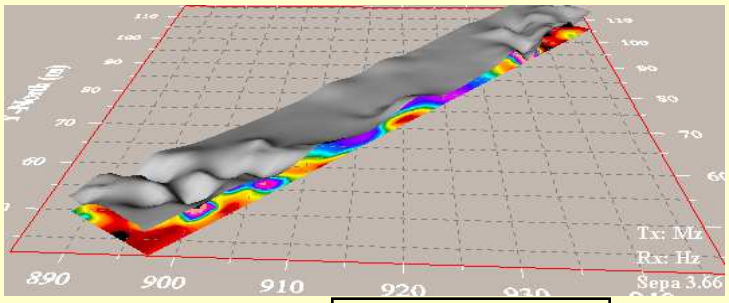
Uranium Exploration

Urban Hazards



Modelling, Inversion, Data Analyses, Research

Applications



Road Construction

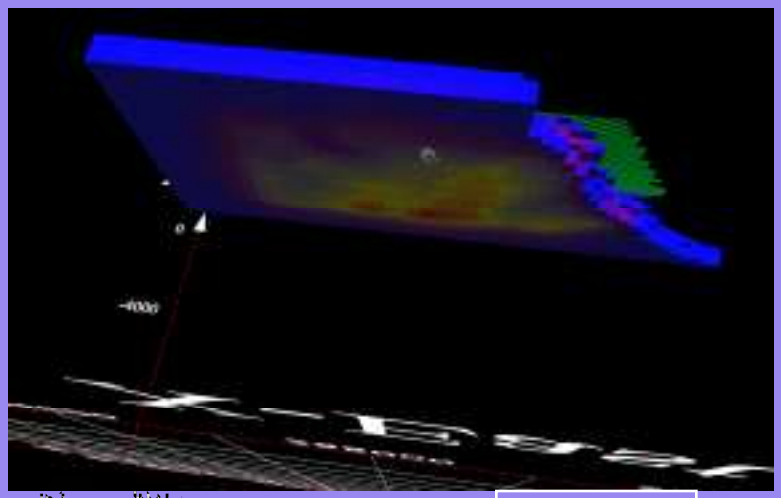
FEM
MAGNETICS
AEM
HEM
CSAMT
TEM
IP
RESISTIVITY
GRAVITY
MT

BOREHOLE
SURFACE
AIRBORNE
CROSSHOLE

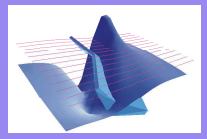
- ✓ Mining Exploration and Delineation
- ✓ Environmental Detection and Monitoring
- ✓ Geotechnical Investigations
- ✓ Oil and Gas Exploration
- ✓ UXO

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

PetrosEikon **products**



Gold Deposit

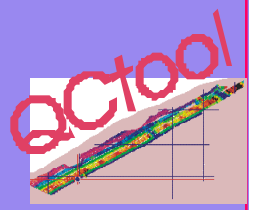


EMIGMA V8.1

Database application
Data editing , filtering, and analyses
Gridding, Contouring and Visualization
Data Simulation and inversion
Imaging techniques
mapping applications
Potential field FFT processing
Aeromagnetic compensation

GEOTUTOR IV

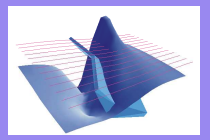
- Education, research and training
- Modeling based
- To teach and understand the fundamental physical principles



QCTool

Data evaluation and processing
Data plotting and gridding
Data editing, spreadsheet, filtering
Binary “database” file

PetRos EiKon services



- **Survey design, survey supervision and quality control for airborne, ground or borehole surveys**
- **Processing, maps and data interpretation**
- **Inversion and modeling services**
- **Ground Surveys – TEM, FEM, Magnetics, Gravity**

Mining – (majors,juniors,consultants,universities)

- ✓Since 1994
- ✓ Detection, Delineation, Survey Design
- ✓Airborne, Surface and Borehole
- ✓Over 20 EM systems, total field and gradient magnetics, IP, tensor and scalar gravity

Near-Surface – (consultants, governments, universities)

- ✓Since 1998
- ✓ data evaluation, gridding, and presentation
- ✓ Inversion and Modelling
- ✓FEM, TEM , Magnetics, Gravity
- ✓UXO, Groundwater, Geotechnical, Archeological

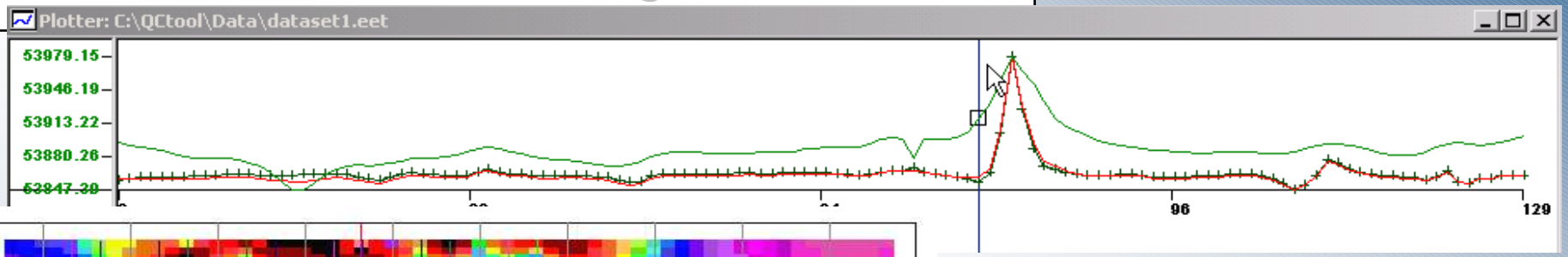
Academics – (over 100 universities worldwide)

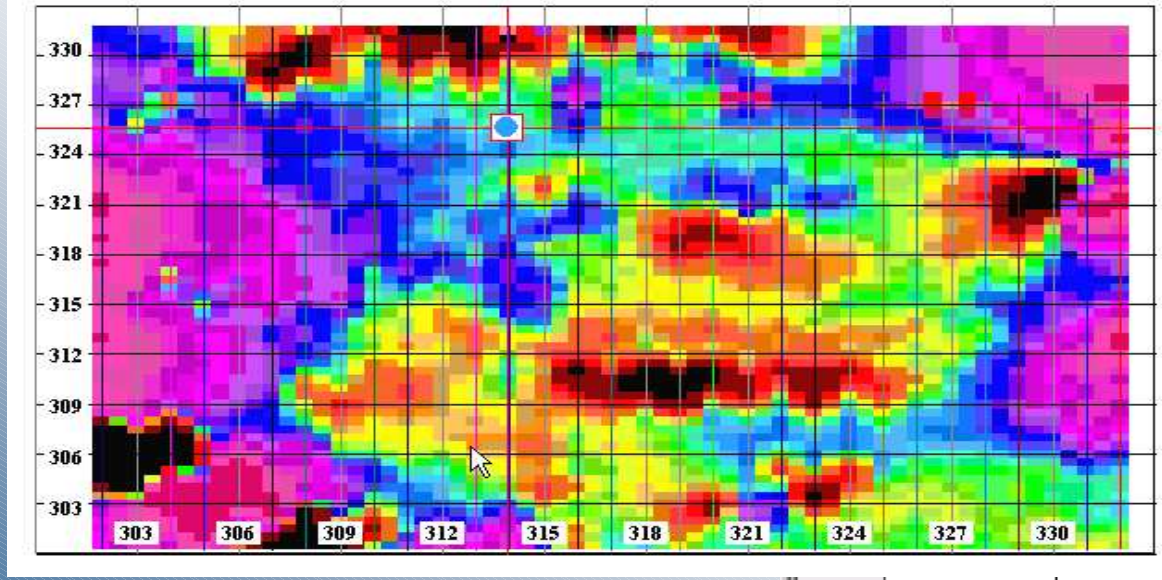
- ✓Since 1995
- ✓Teaching and Research
- ✓Environmental, UXO, mining, Oil and Gas
- ✓EM, Magnetics, Gravity
- ✓Modelling, Inversion, Survey Design

Oil and Gas – (consultants and juniors)

- ✓Since 2000
- ✓ Airborne magnetics, EM, Gravity, MT
- ✓Survey Design, Processing, Geological modelling, inversion
- ✓CSEM, MTEM, ZTEM, MT, CSAMT, IP

QCTool



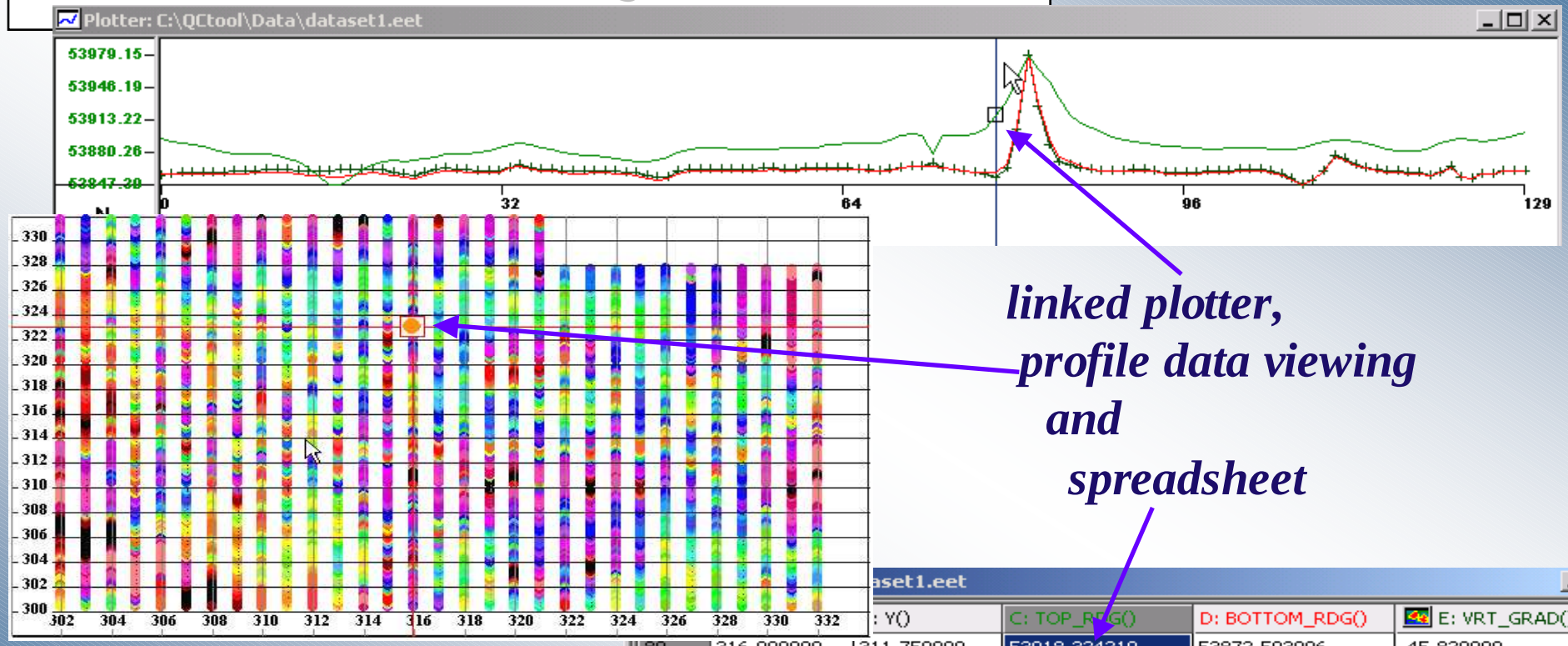


for data Quality Control
editing, plotting, gridding
and filtering

			C: TOP_RDG()	D: BOTTOM_RDG()	E: VRT_GRAD()	F:
0			53918.324219	53872.503906	-45.820000	14
0			53934.011719	53942.500000	8.487000	14
82	316.000000	311.250000	53956.031250	54217.406250	261.376007	14
83	316.000000	311.000000	53979.148438	54720.160156	741.010986	14
84	316.000000	310.750000	53965.941406	54378.589844	412.648987	14
85	316.000000	310.500000	53953.113281	54117.082031	163.968002	14
86	316.000000	310.250000	53935.222656	53991.089844	55.866001	14
87	316.000000	309.779999	53919.246094	53949.285156	30.039000	14

Aeromagnetic Diamond Exploration

QCTool 2

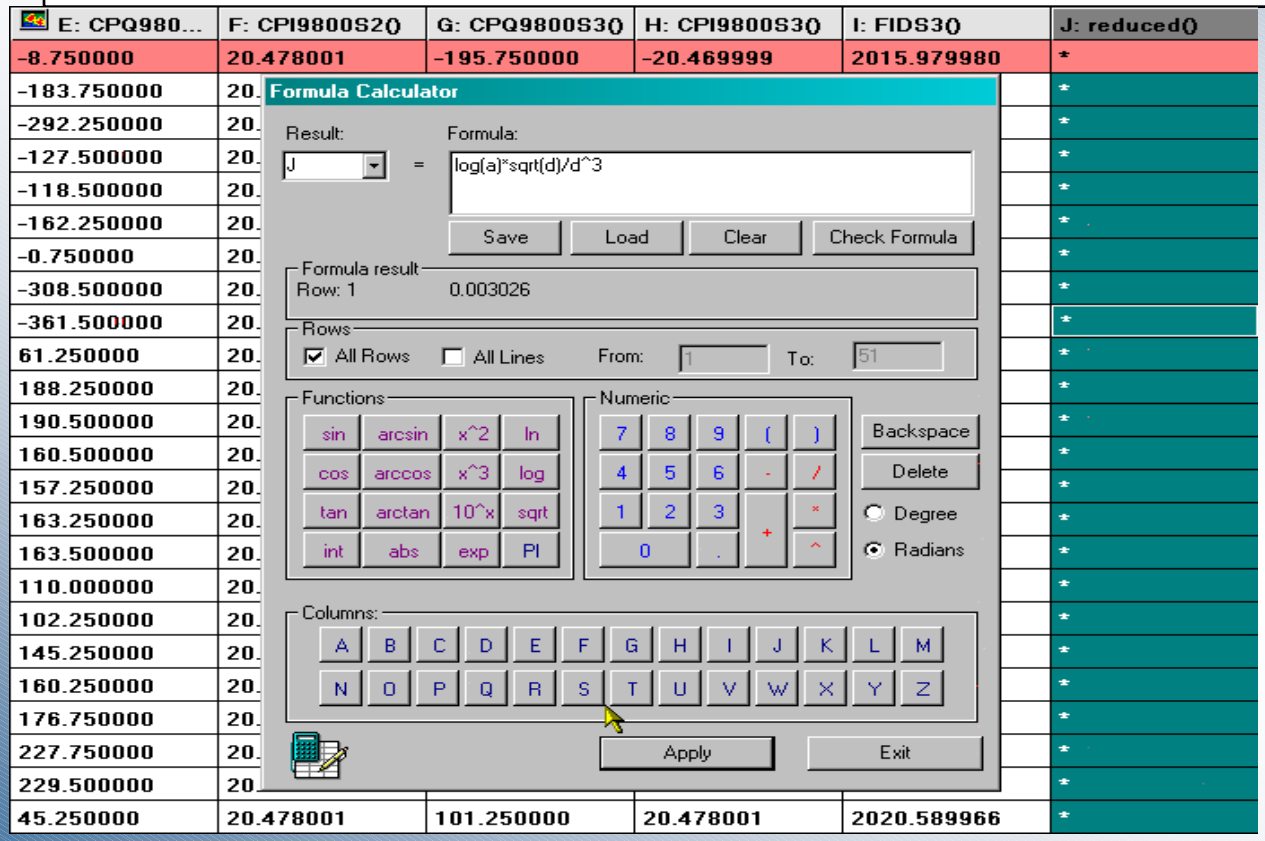


linked plotter, profile data viewing and spreadsheet

aset1.eet

	Y()	C: TOP_RDG()	D: BOTTOM_RDG()	E: VRT_GRAD()	F:
80	316.000000	311.750000	53918.324219	53872.503906	-45.820000	14
81	316.000000	311.500000	53934.011719	53942.500000	8.487000	14
82	316.000000	311.250000	53956.031250	54217.406250	261.376007	14
83	316.000000	311.000000	53979.148438	54720.160156	741.010986	14
84	316.000000	310.750000	53965.941406	54378.589844	412.648987	14
85	316.000000	310.500000	53953.113281	54117.082031	163.968002	14
86	316.000000	310.250000	53935.222656	53991.089844	55.866001	14
87	316.000000	309.779999	53919.246094	53949.285156	30.039000	14

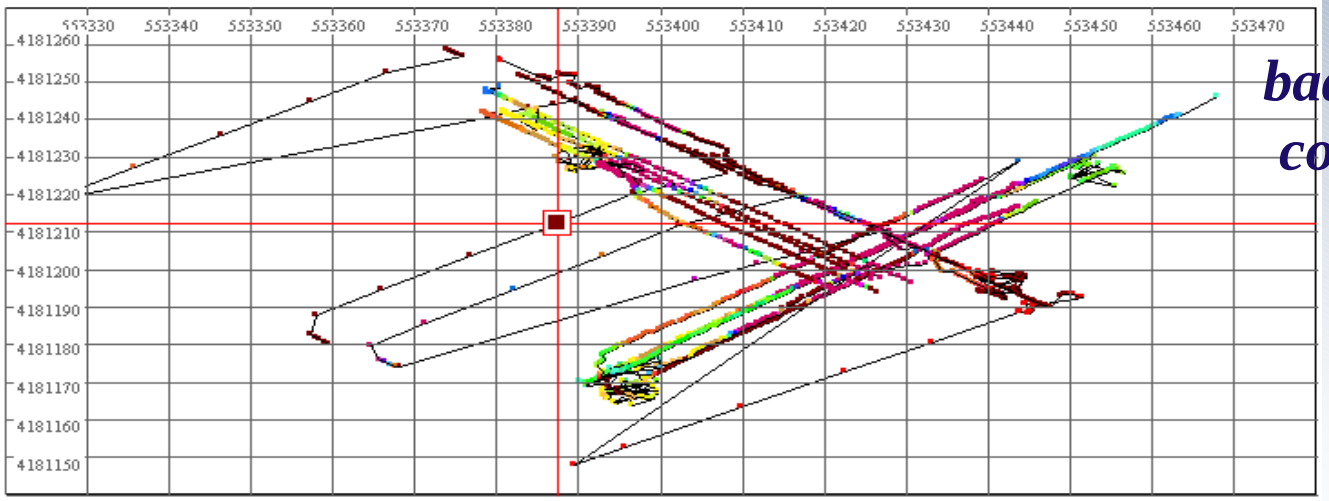
QCTool 3

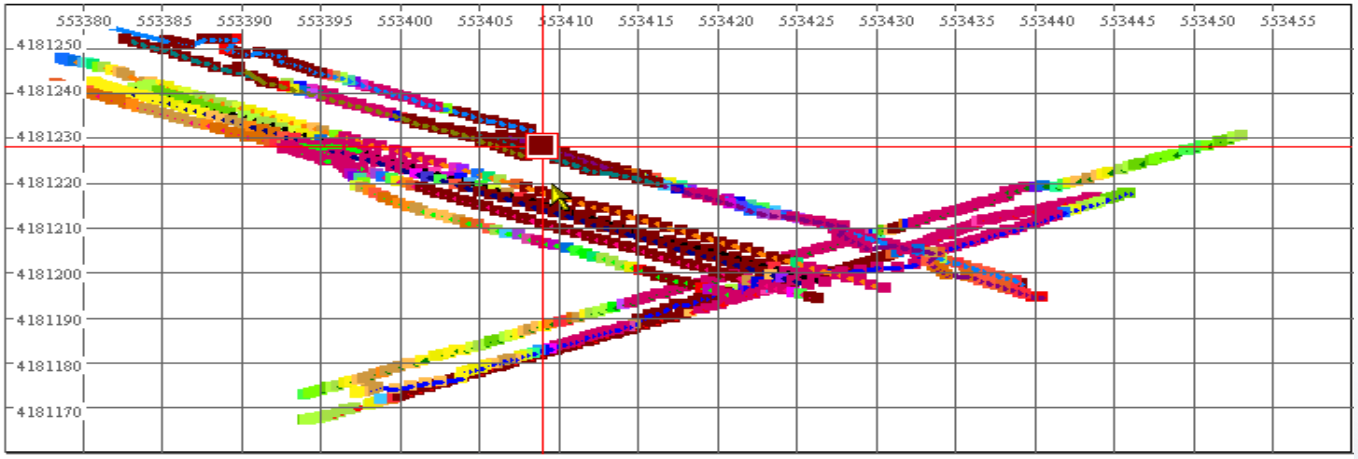


Spreadsheet functions
new channels calculator

QCTool 4

Survey Cleaning



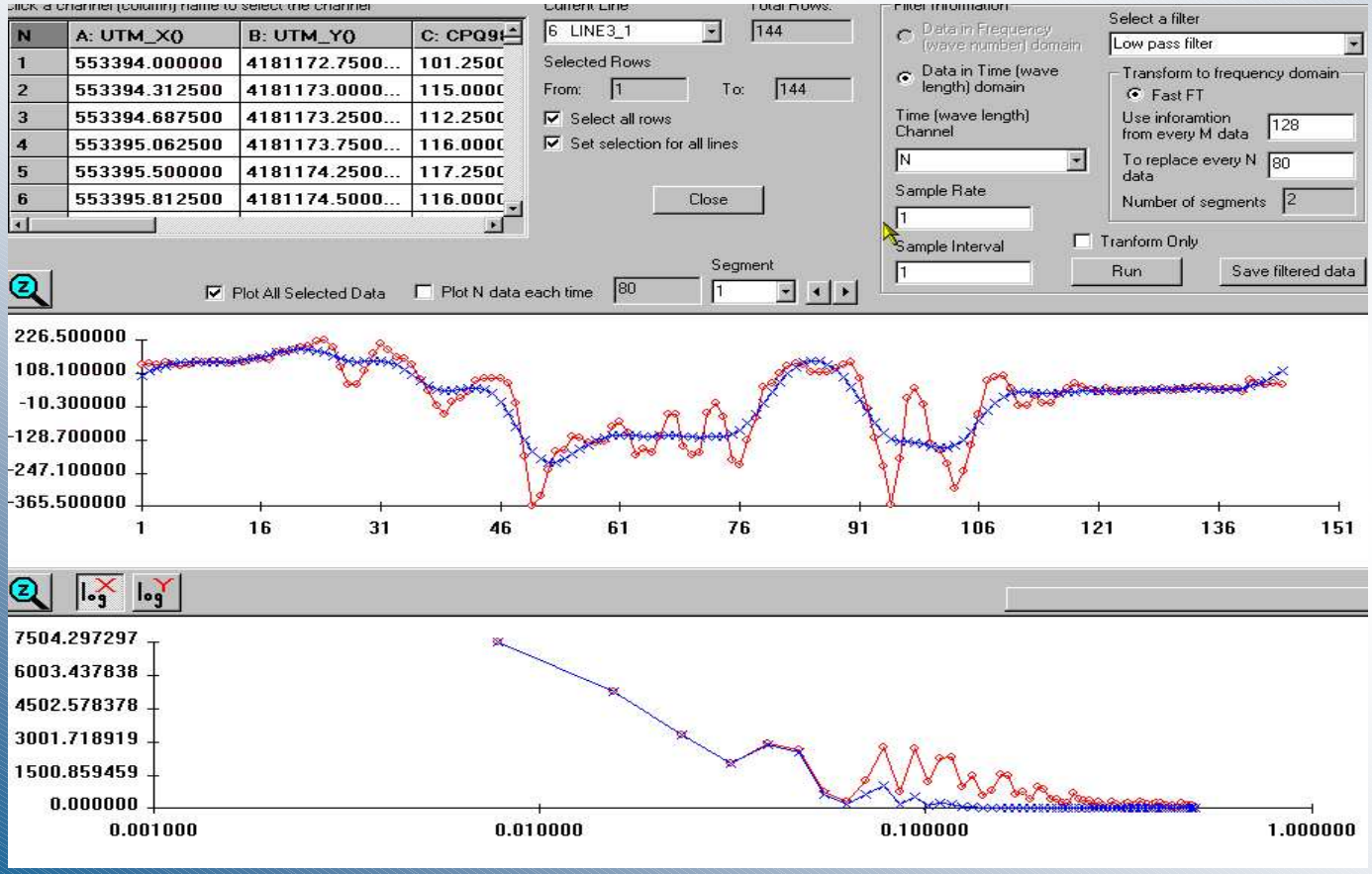


bad data location editing
coloured data displays

Munitions Testing Site ground FDEM

QCTool 5

Data Filtering
Spectrum Analyser
Raw vs filtered overlays



data

spectra

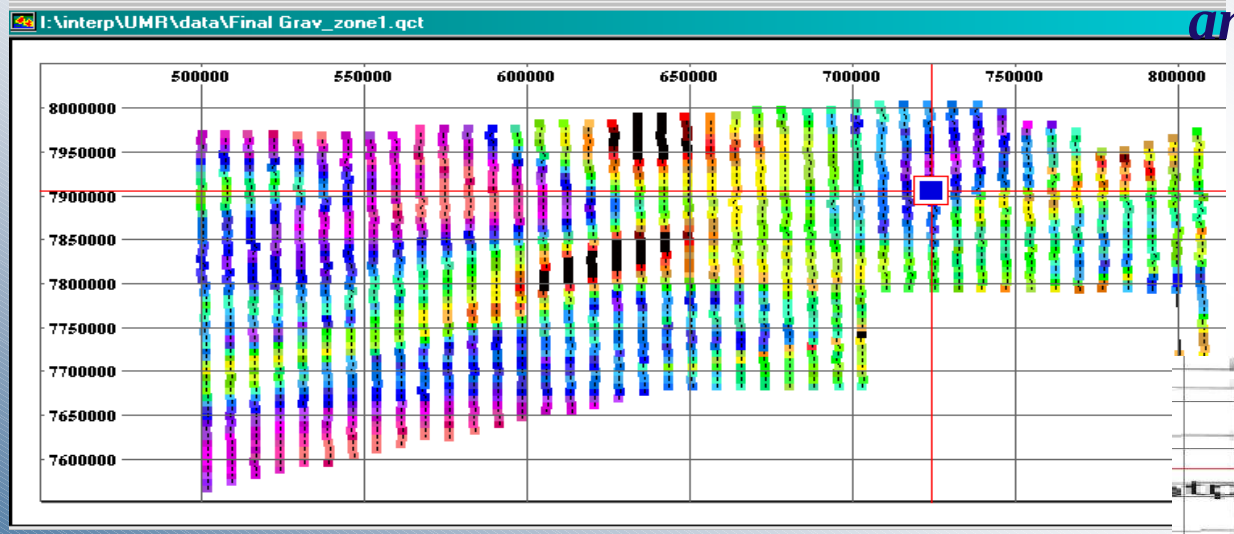
QCTool 6

NEW

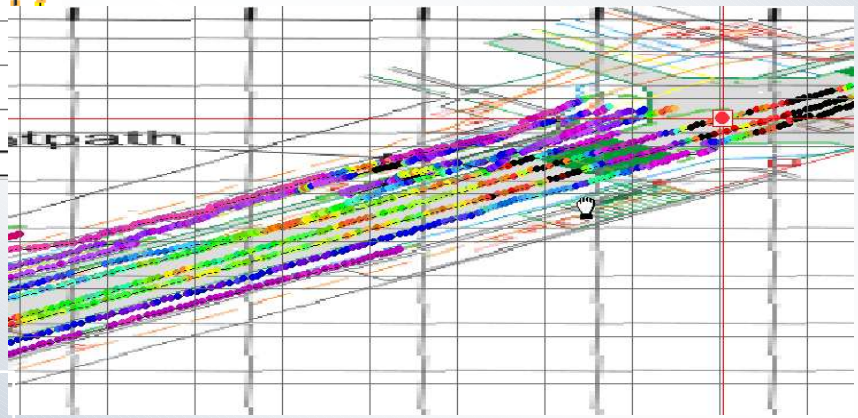
N	B: LongCLK80	C: LatCLK80	D: UTM_X(m)	E: UTM_Y(m)	F: ELevCLK80	G: Boug	H:
16	23.131243	-18.917564	724464.529415	7906939.9167...	959.184998	-127.524002	*
17	23.126765	-18.858158	724071.698391	7913522.3390...	961.205994	-131.076996	*
18	23.123974	-18.794565	723861.825479	7920565.9387...	959.140015	-130.164993	*
19	23.122980	-18.719899	723855.544173	7928833.1785...	956.794983	-133.757996	*
20	23.121977	-18.652397	723838.507477	7936307.1768...	956.679016	-135.229004	*
21	23.121447	-18.582739	723873.797886	7944019.3526...	955.901978	-133.311996	*

Mapping

non-convex local contouring and map underlays

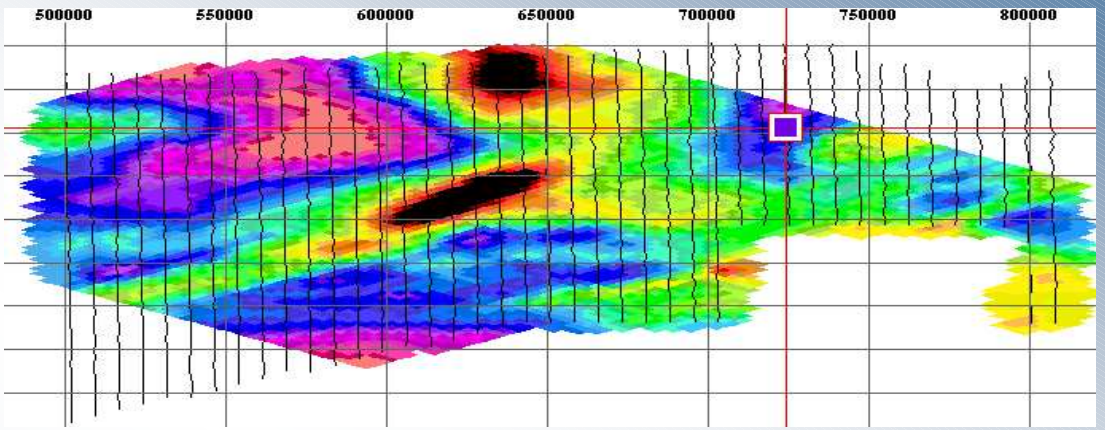


Uranium Exploration – airborne TEM



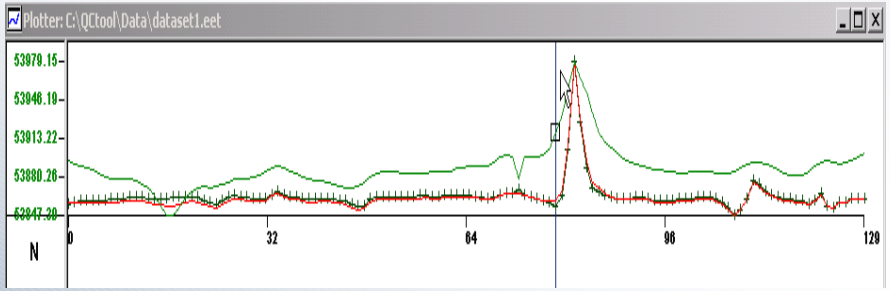
Fuel Dump contamination – EM31-3

QCTool 7



- *Easy to use*
- *Low cost*
- *Large or small datasets*
- *Small installation*
- *Perfect for infield QC*
- *Imports & Exports*

  Excel, Binary/ASCII XYZ, Geosoft, Smartmag, CG5
- *Data Merging*
- *Map Calibration, Annotation and data overlays*



EMIGMA V8.1
Sophisticated software for the practicing Geoscientist

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

EMIGMA Tools

EMIGMA V8.1

Sophisticated software for the practicing Geoscientist

- *Data analyses and editing tools*

- *3D Visualization*
- *3D Model Building*
- *CAD Model Imports*

- *3D Data Simulation – instrument calibrated – Magnetics,Resistivity,Gravity,EM,IP,MT*

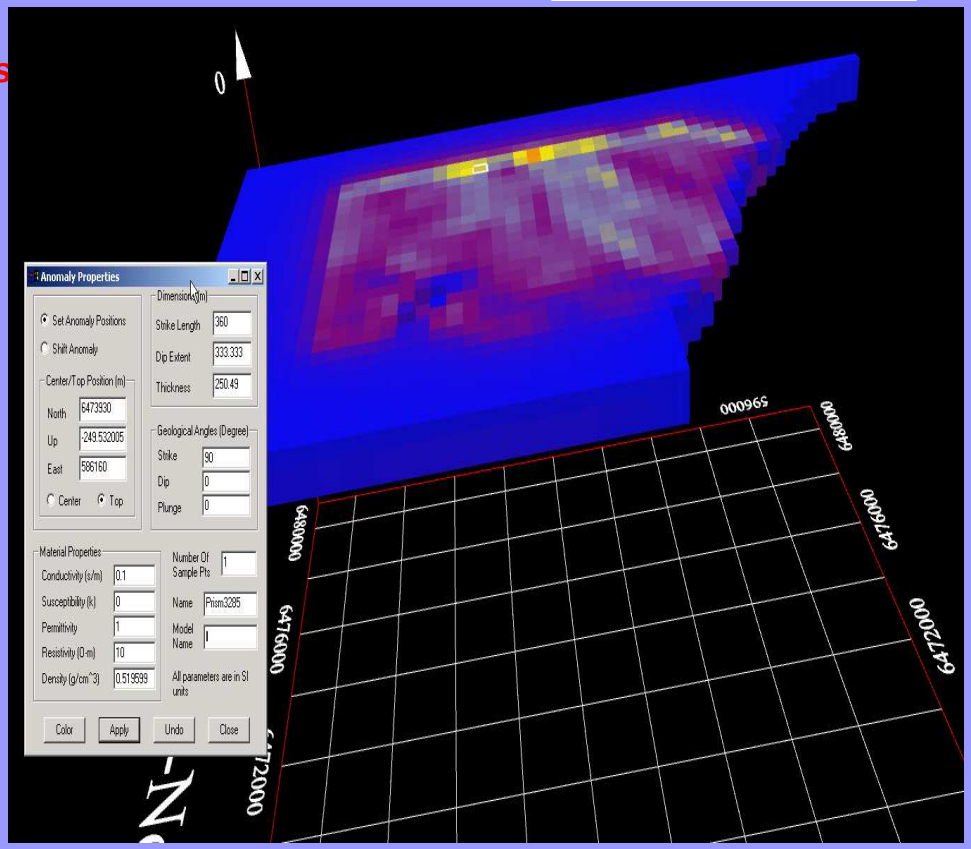
- *3D Magnetic Inversion, 3D Gravity Inversion*
- *1D FEM, TEM and Resistivity Inversion*
- *FEM, TEM, Resistivity Pseudo-Depth and Geoelectric Sections*

- *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*

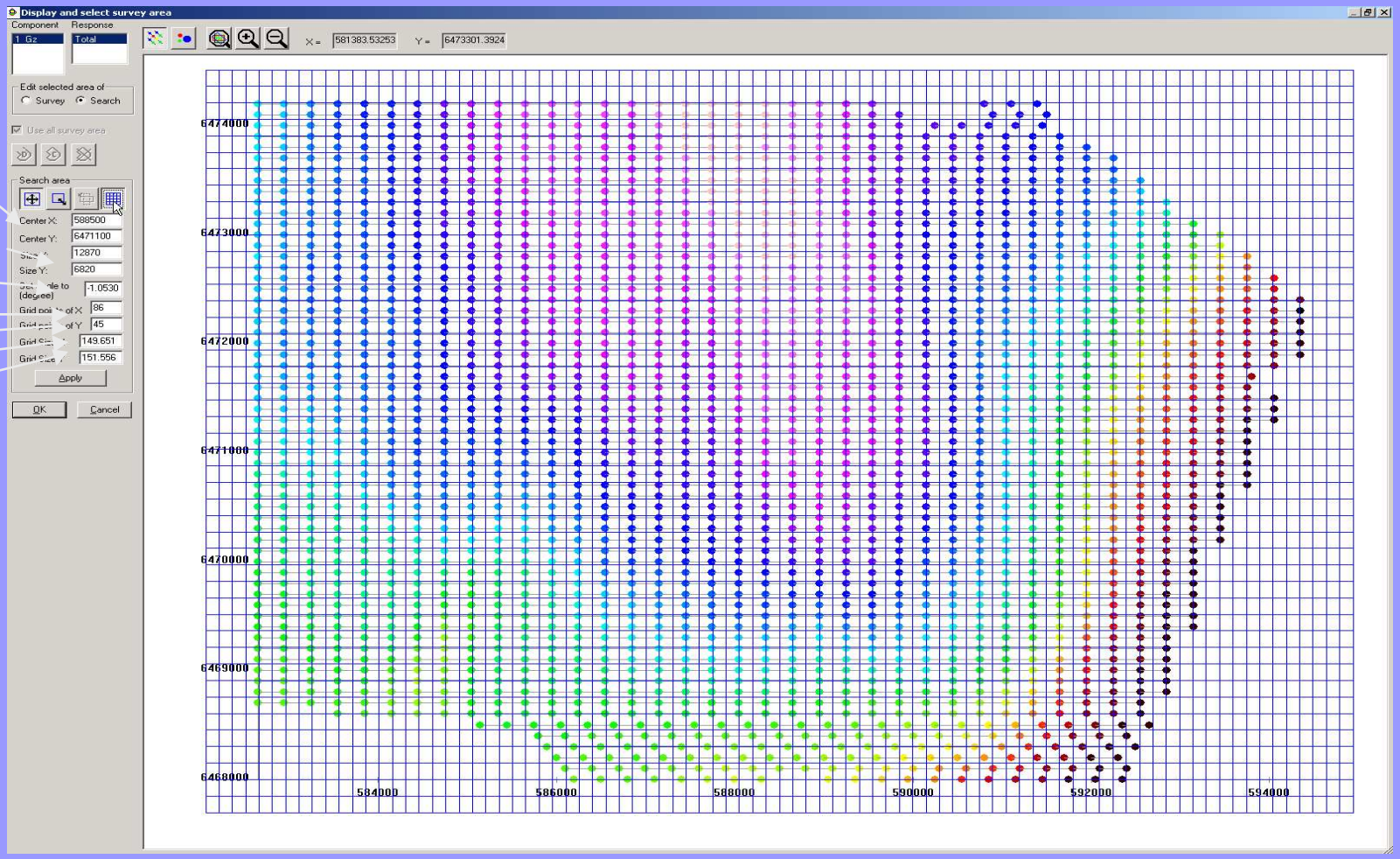
- *Model Stripping*
- *Potential field data transforms – filtering, continuation, RTP*
- *Magnetic and Gravity Gradients*
- *Magnetic Compensation*
- *Xhole Tomography*

- *Gravity – 3D Modeling and Inversion*
- *3D Euler and Post-Processing including 3D Visualization*
- *FFT tools*
- *(basic data processing also available)*

Ground Gravity Inversion



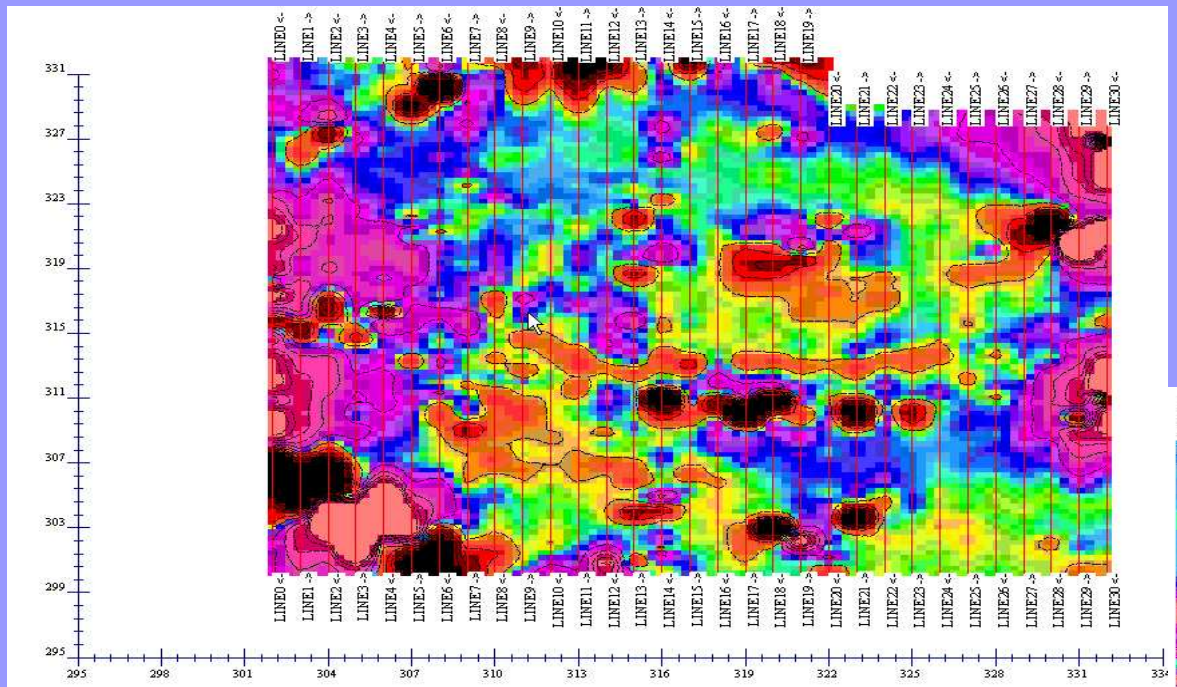
the data may be shown and the interface allows the user to define the inversion or "search" grid



Data Interpolation and Contouring 1

Natural Neighbour, Shepard, Delauney - Local

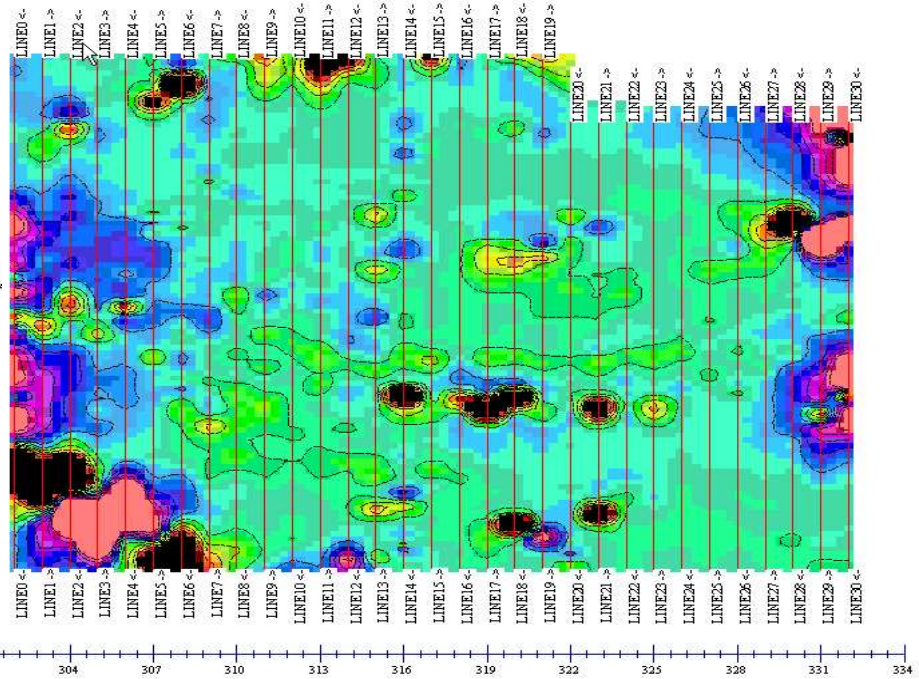
Minimum Curvature - global



Rectangular grid cells

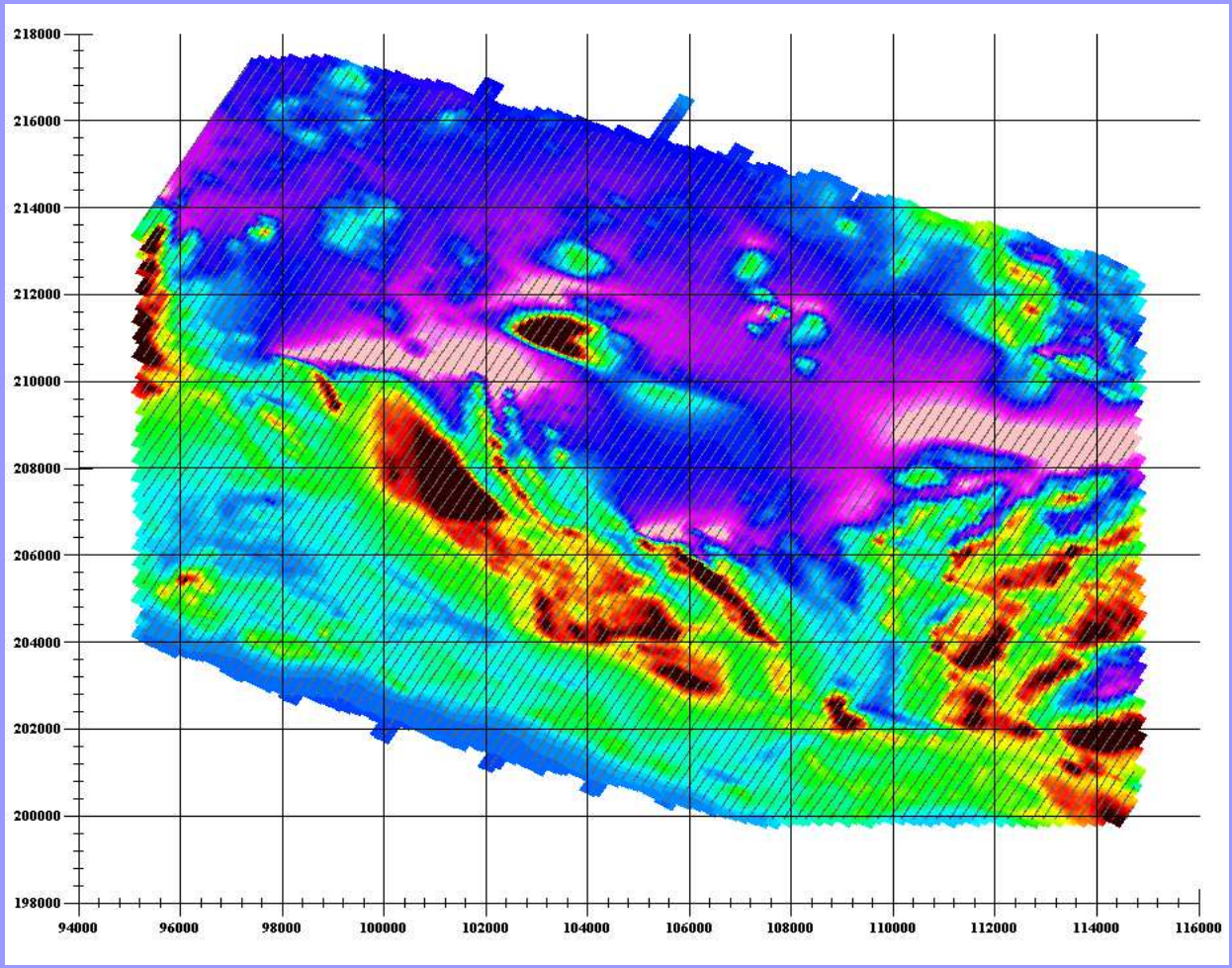
Multi-component grids

Equal Weight



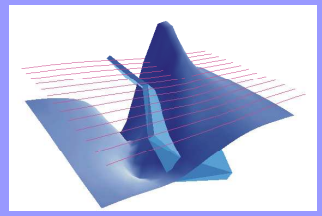
Equal Range

Data Interpolation and Contouring 2

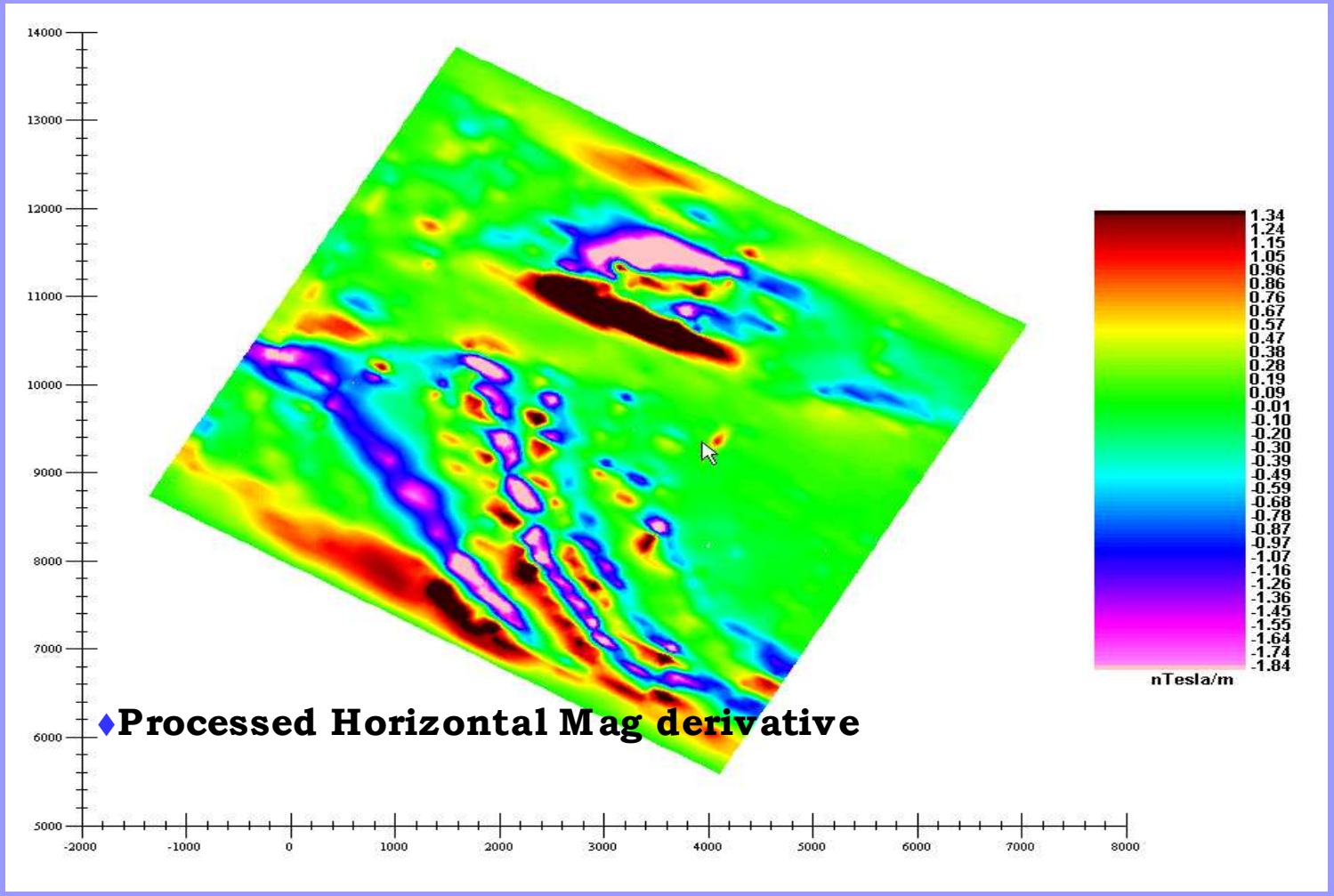


Massive Sulphide Exploration – Spain/Portugal

- ✓ Natural Neighbour Interpolation
- ✓ Delauney Traingulation
- ✓ Minimum Curvature
- ✓ Splines

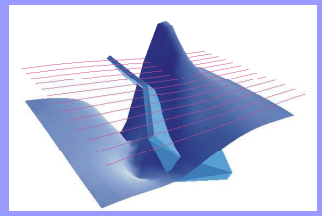


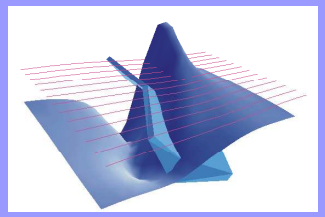
Data Interpolation and Contouring 3



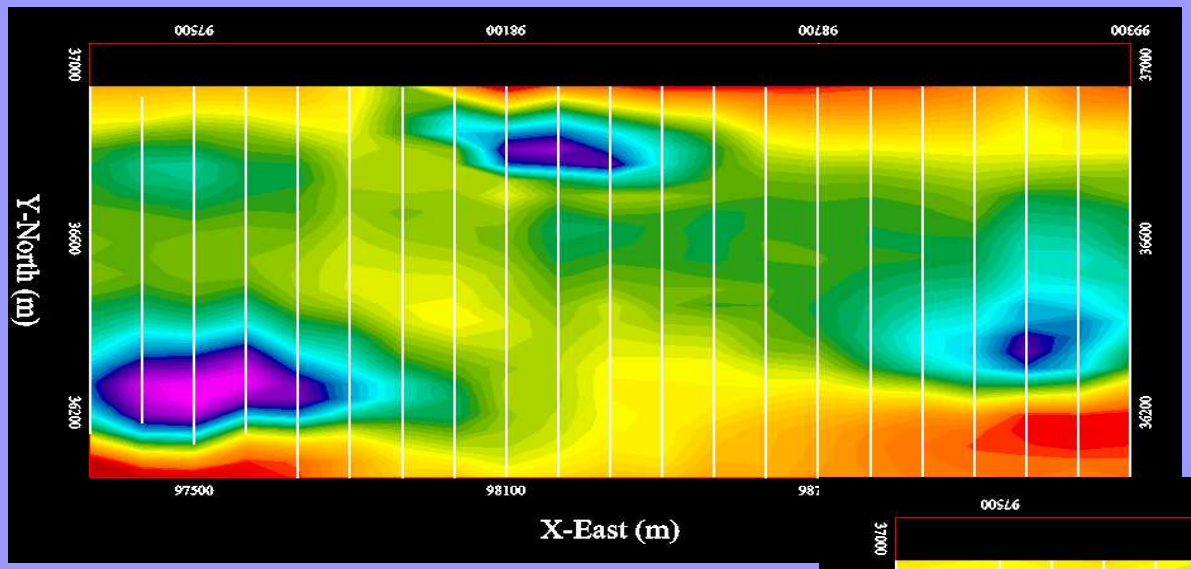
Grid View

Multiple datum stored in a grid for quick viewing

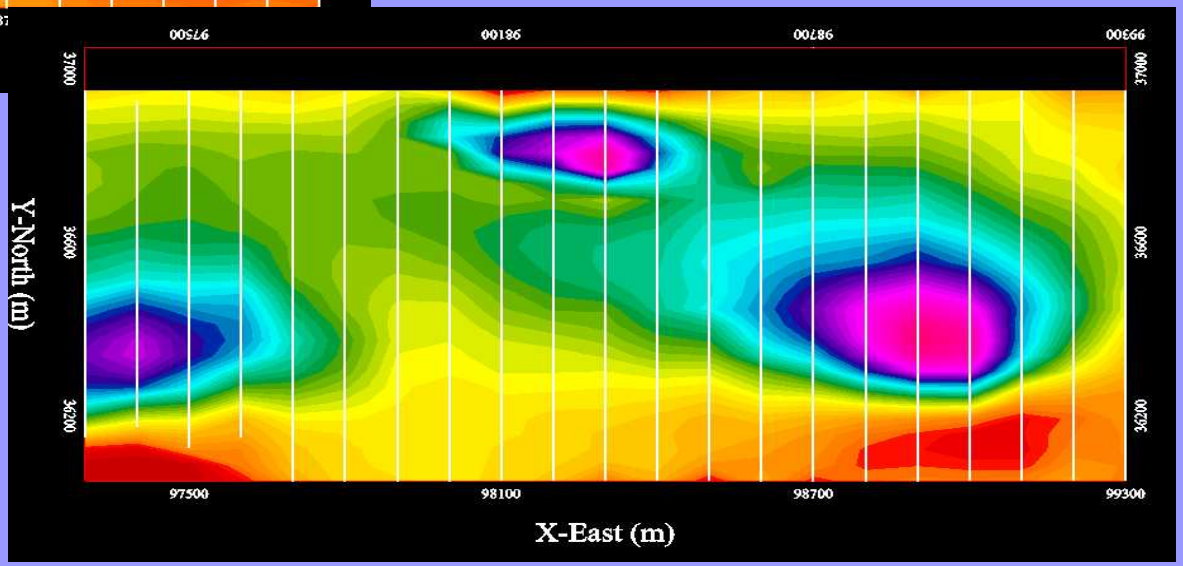




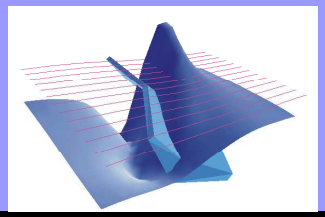
Track anomaly time evolutions



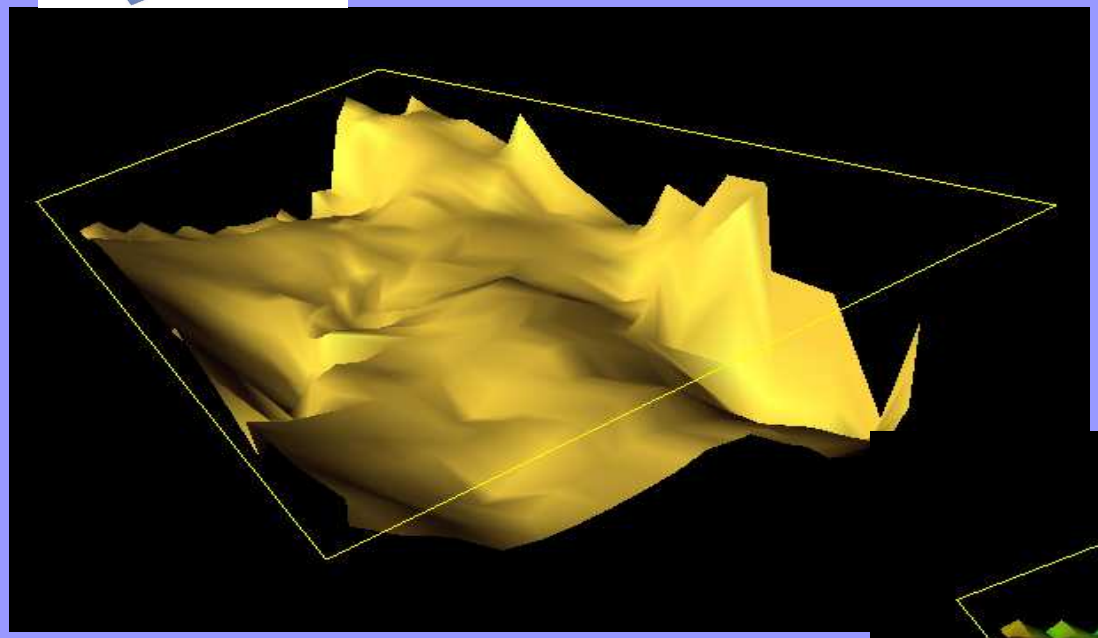
Mid-Time TEM data



Late-Time TEM data

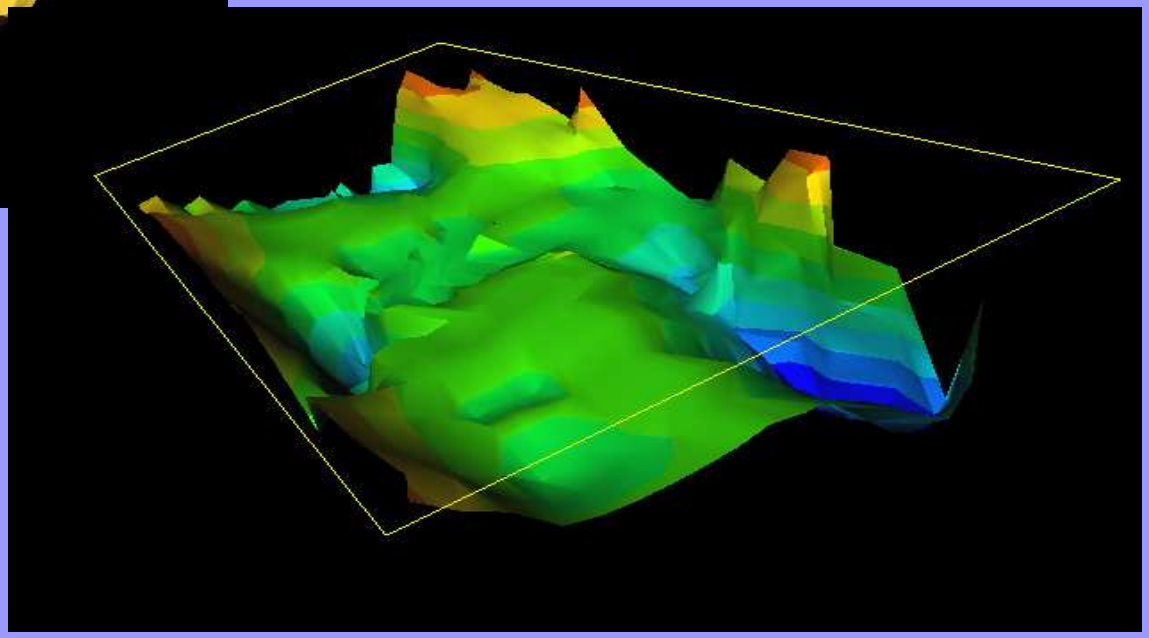


Surface representation of data allows for a spatial display of anomalies



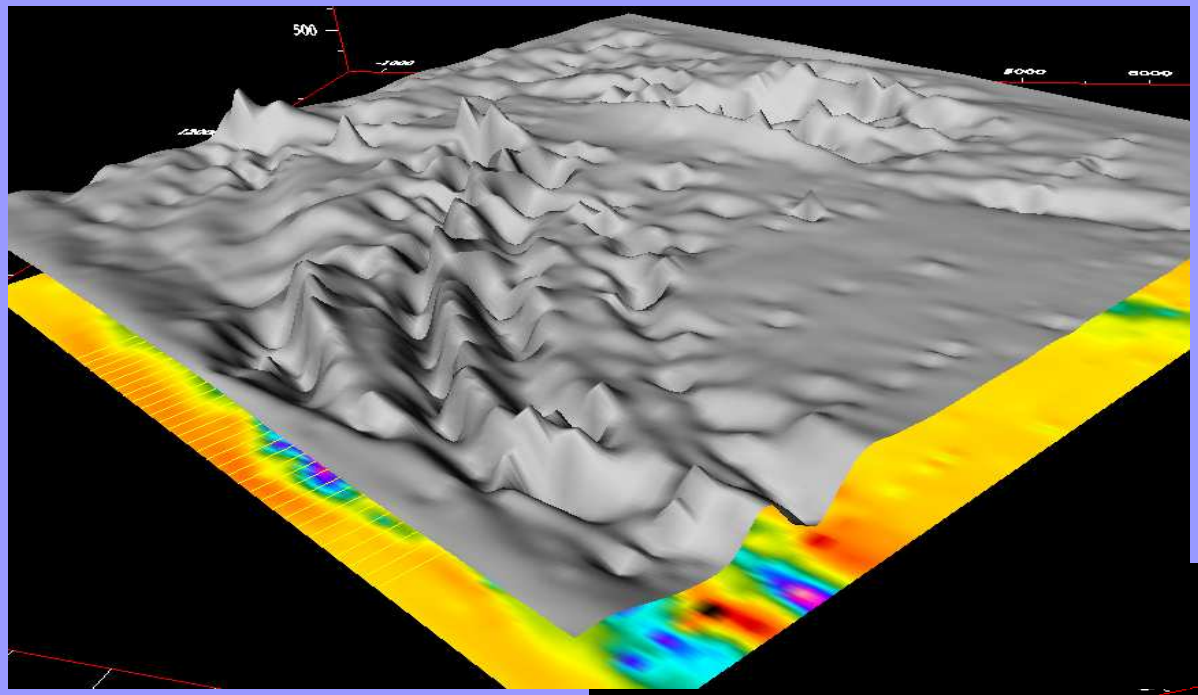
Data Surface

Nickel Exploration – Canadian Arctic



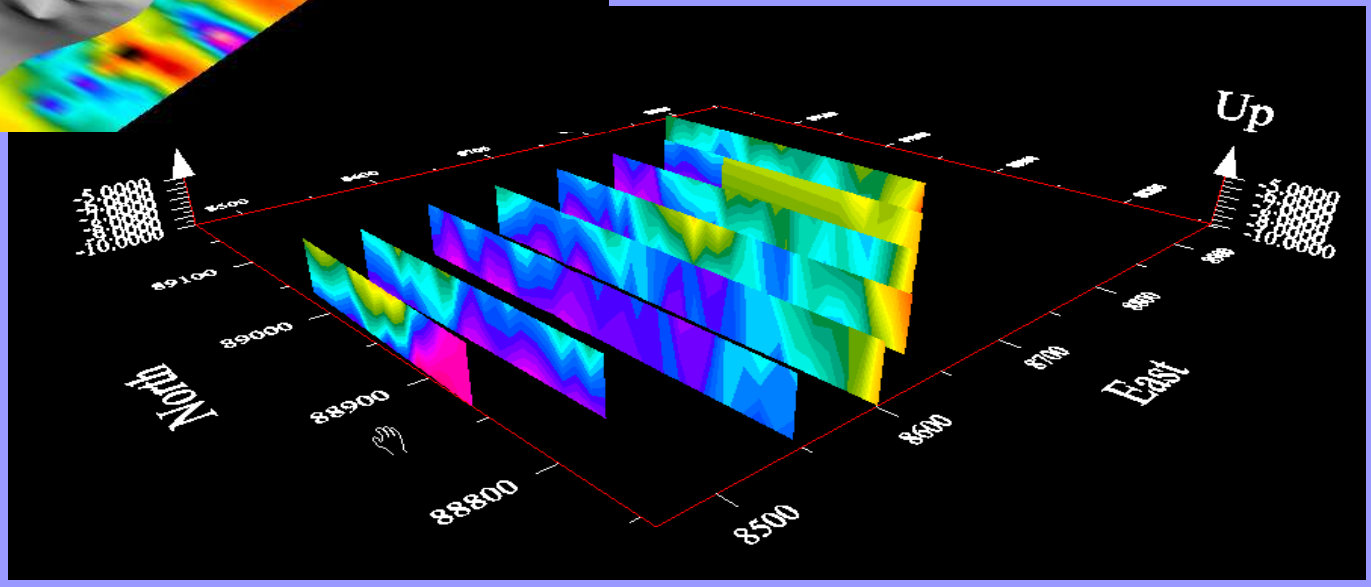
Contoured Data Surface

Data Interpolation and Contouring 4



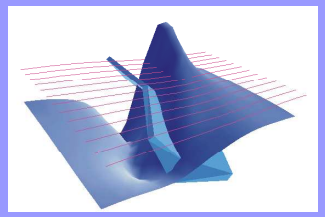
Airborne Gravity – Gulf of Mexico

IP data - Mongolia

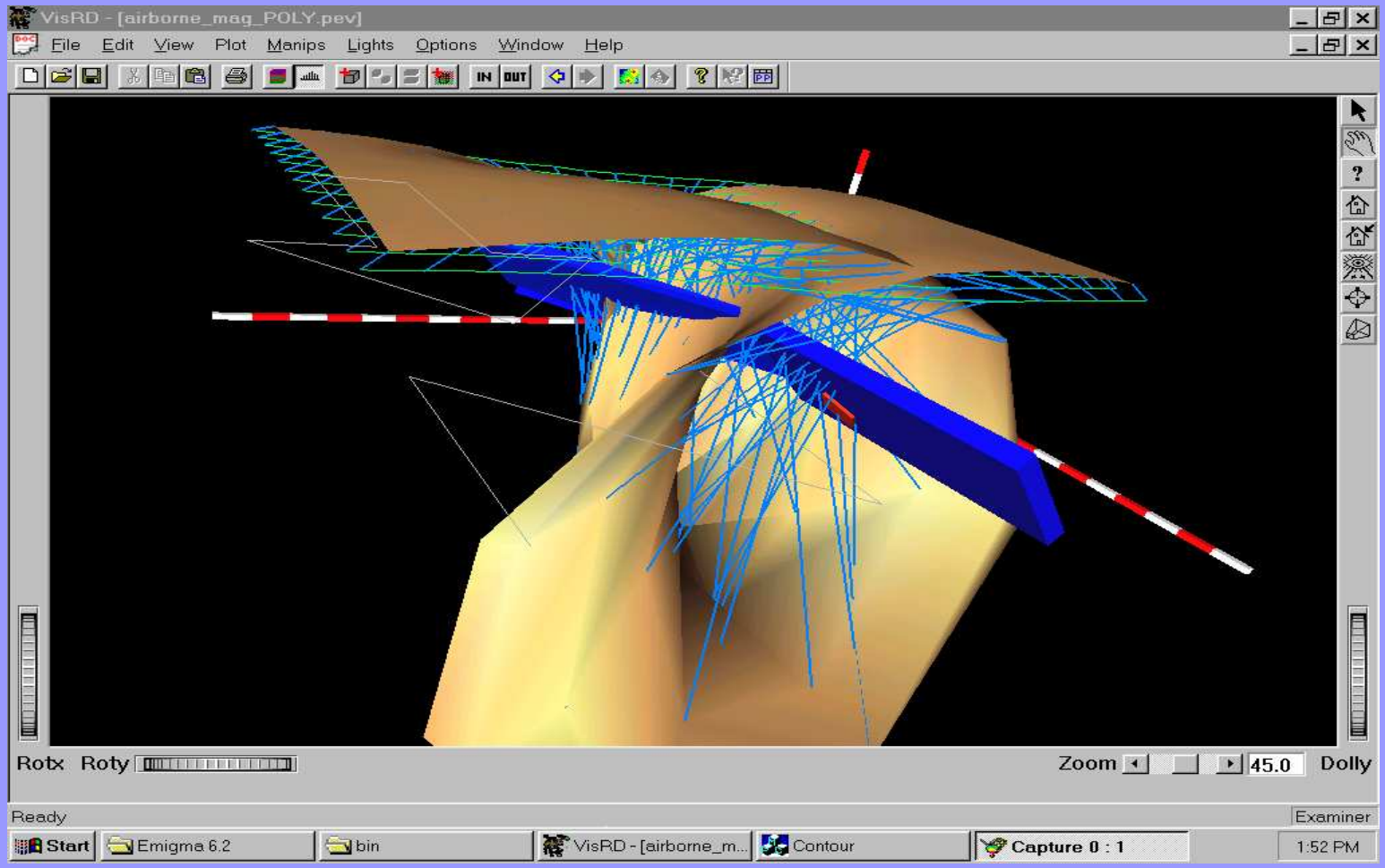


EMIGMA V6.1

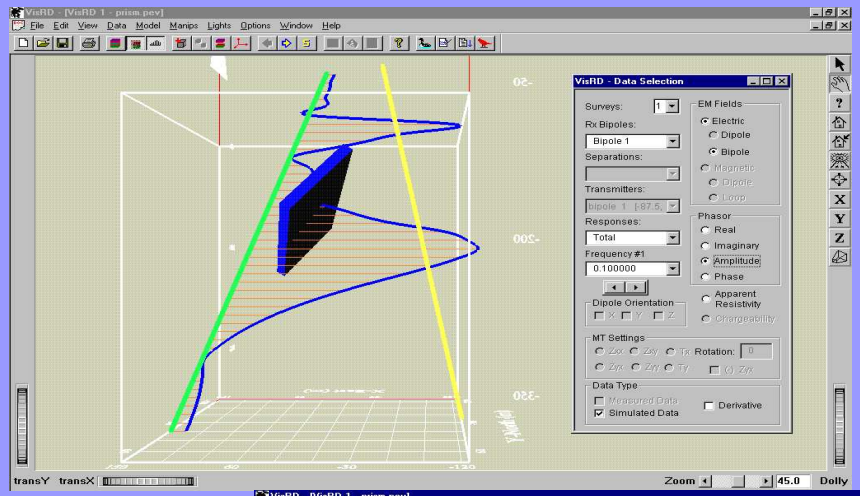
Sophisticated software
for the practicing Geoscientist

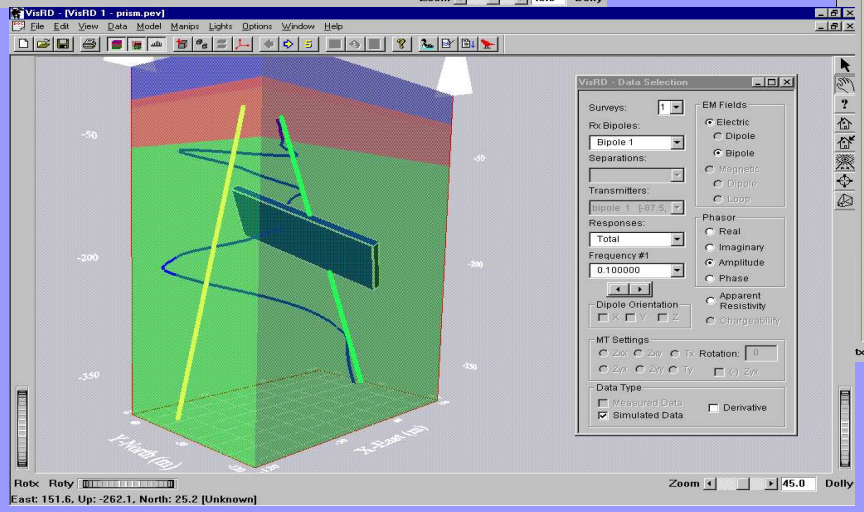


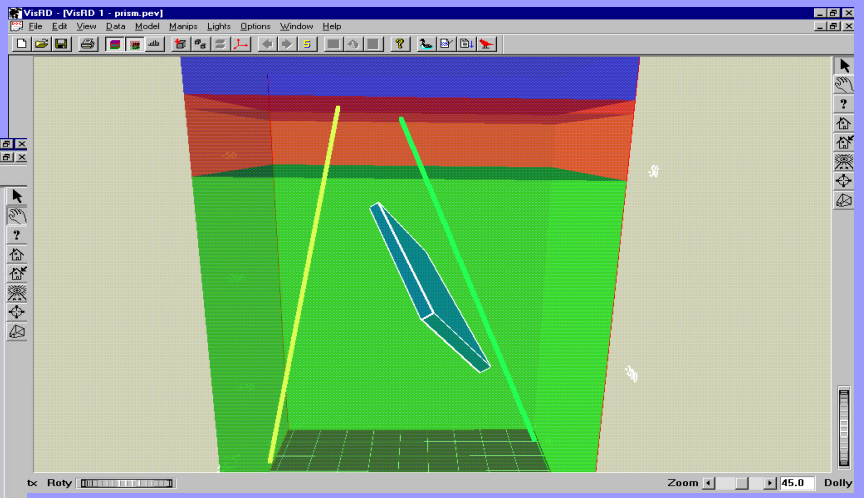
A Range of 3D Data Representations



Model Building and Simulation - 1







View survey, Build models and analyse data in 3D

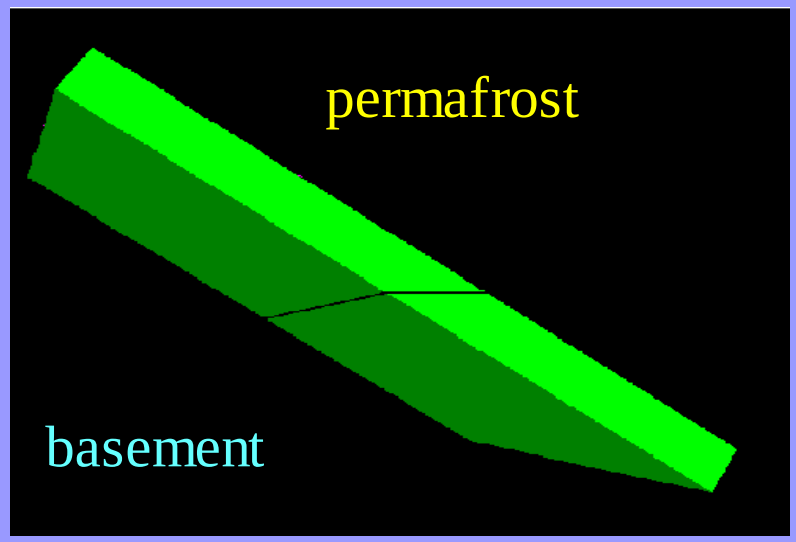
***e.g.* Crosshole resistivity survey and model – gold deposit delineation**

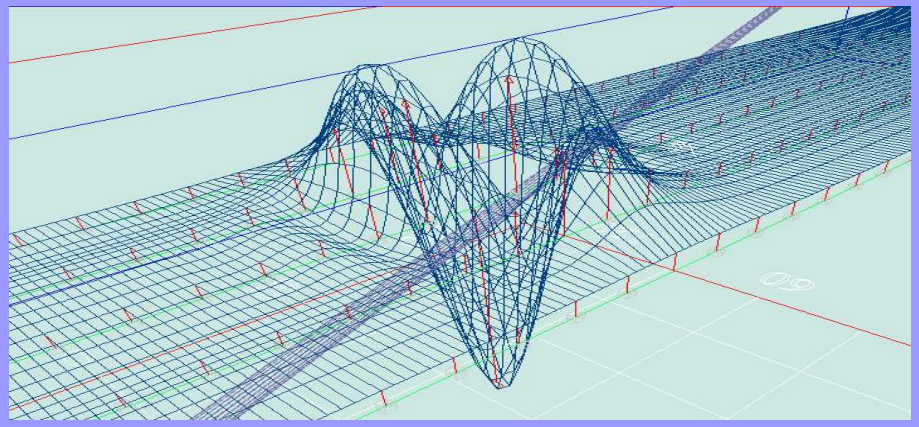
Model Building and Simulation - 2

EM –> TDEM and FDEM

3 Algorithms – 3D integral equation 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**

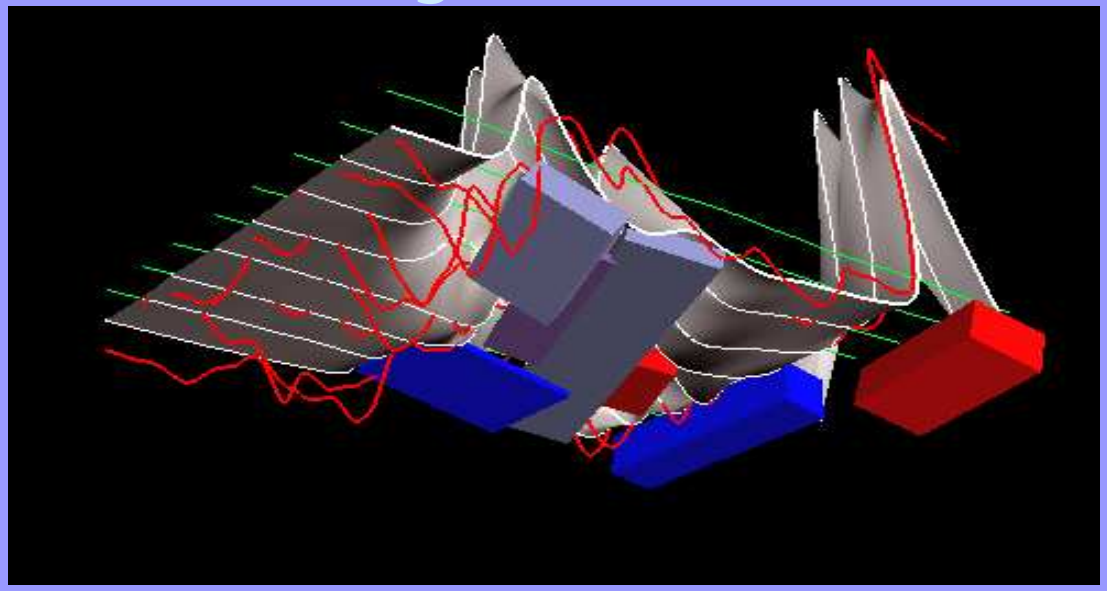




Model Building and Simulation - 3

EMIGMA V6.1

Sophisticated software
for the practicing Geoscientist



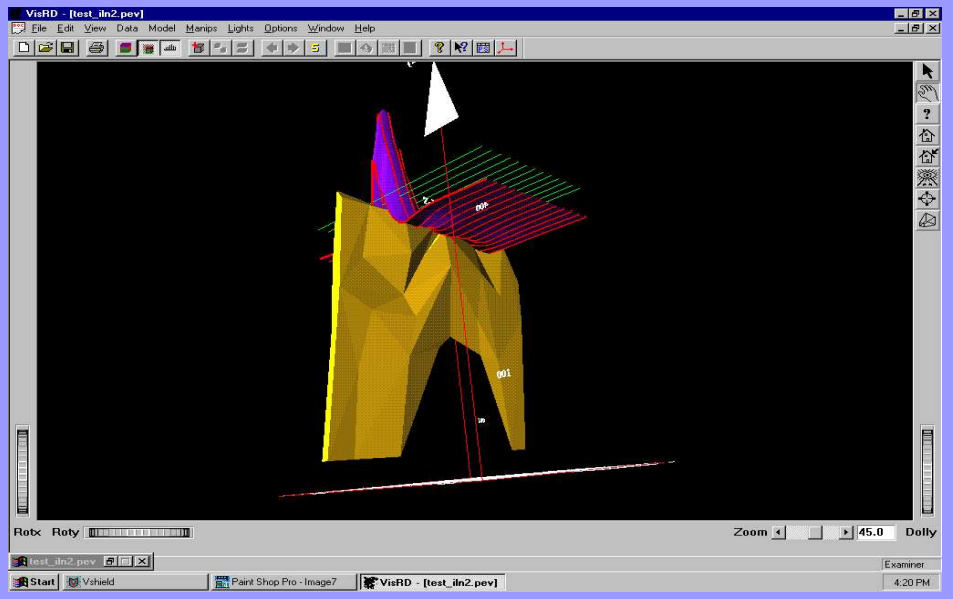
Pb/Zn exploration
Helicopter FEM

Magnetics

- 3 Algorithms – 3D IE
  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)
- Ground, Surface to Borehole, Borehole to Surface, borehole to borehole
- direct comparisons to measured data
- super-engine architecture for large models or surveys

EMIGMA V6.1
Sophisticated software
for the practicing Geoscientist

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

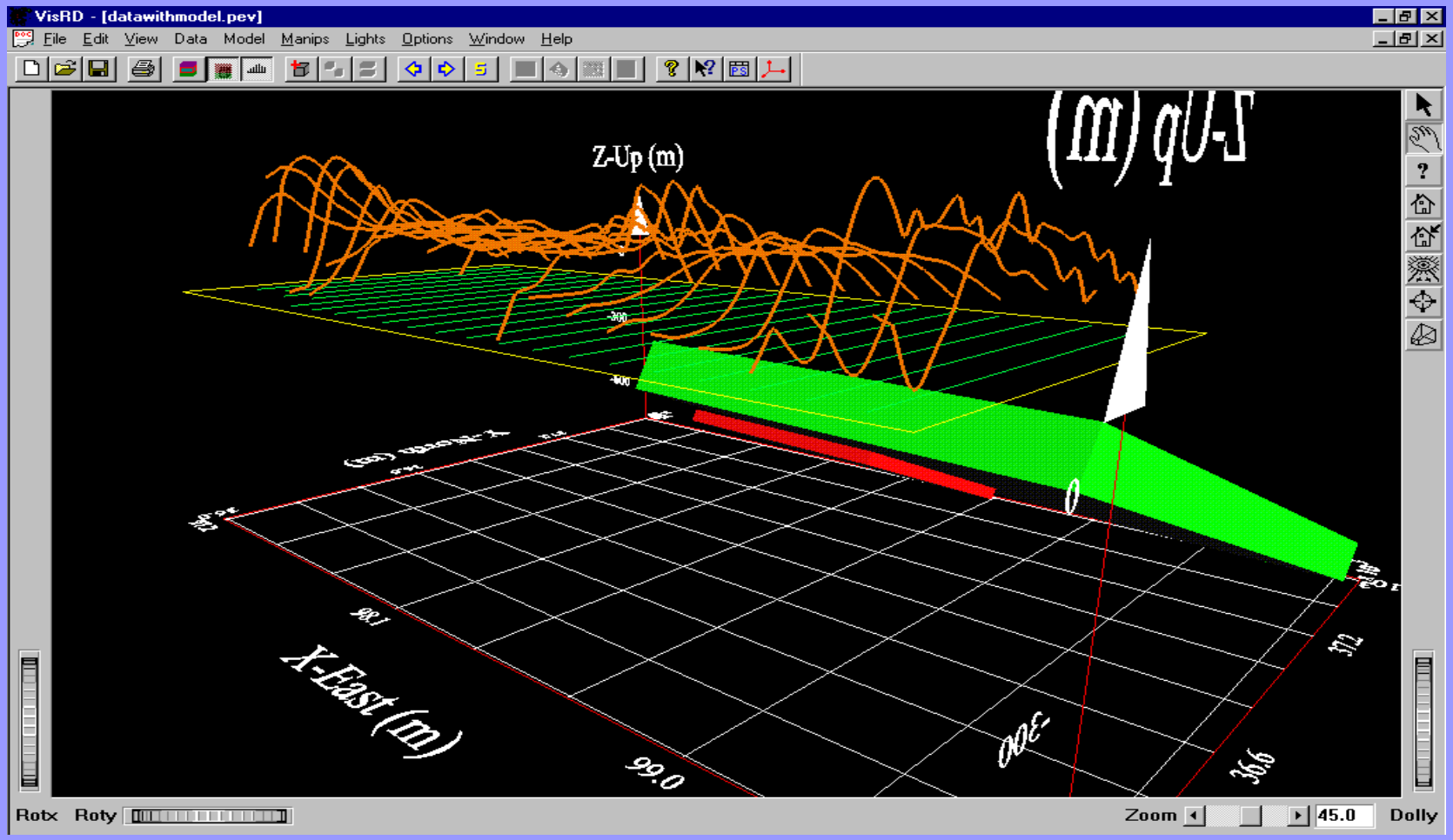
Strong and Weak Interactions

Crosshole

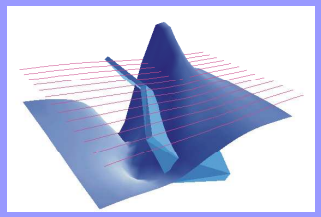
electric (3 antennae types) or magnetic antennae

Experimental Systems

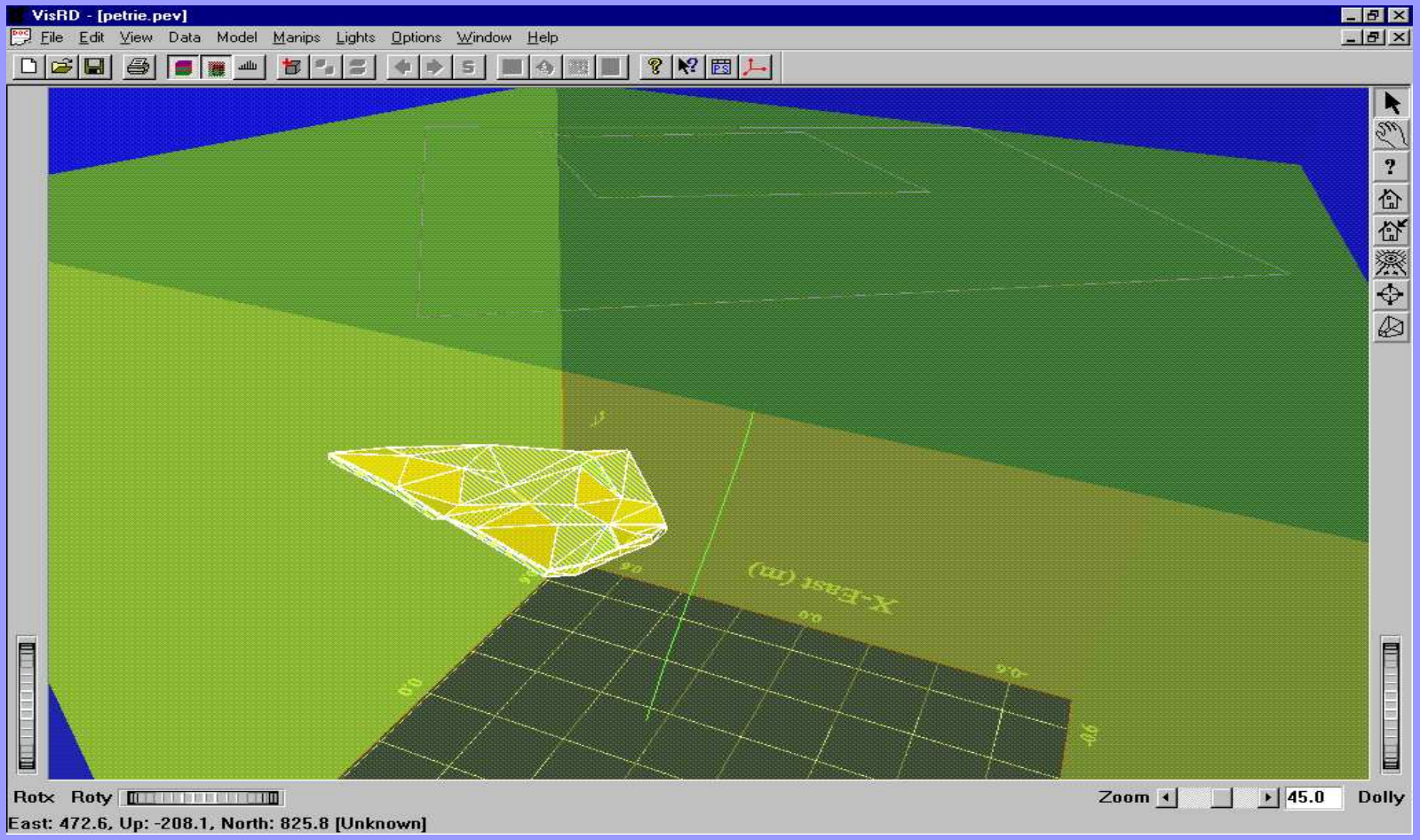
Data and Structure Representation in EMIGMA's 3D Visualizer



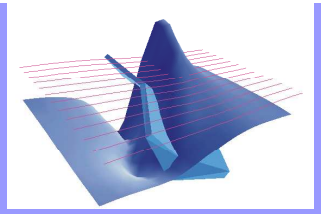
A fully integrated 3D visualization tool



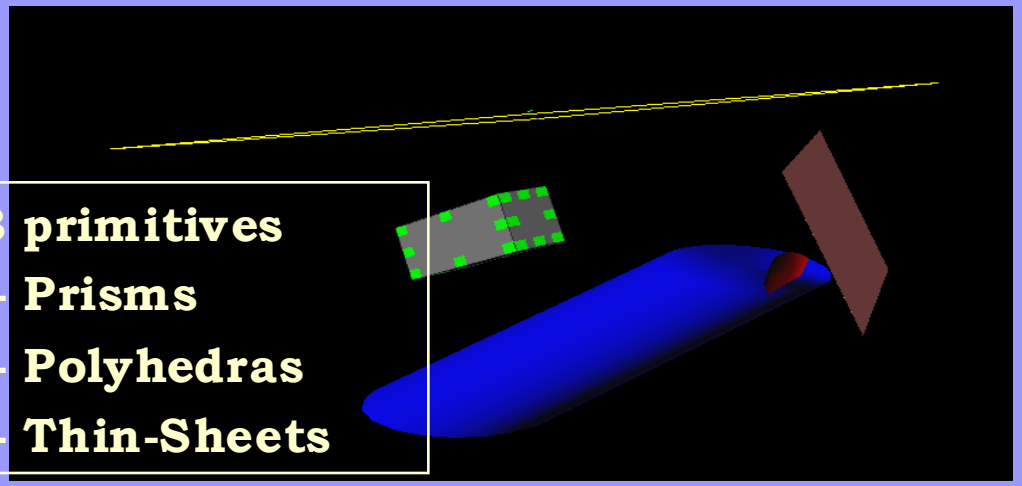
Geological CAD Models



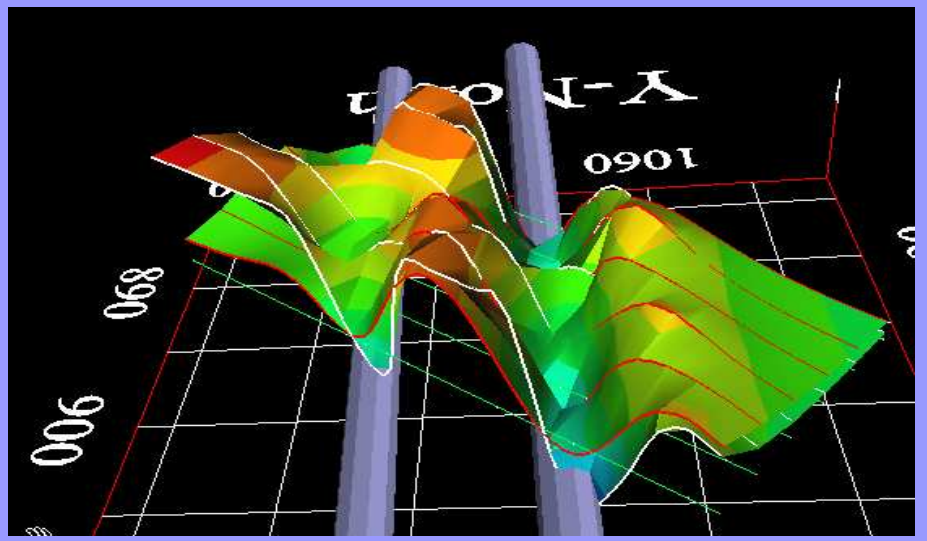
Complex 3D modelling capabilities including imports of geological models from CAD applications

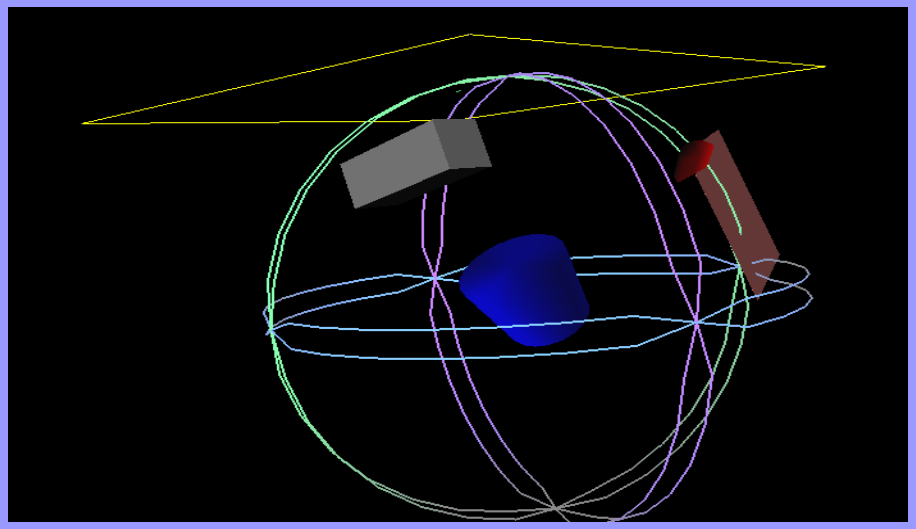


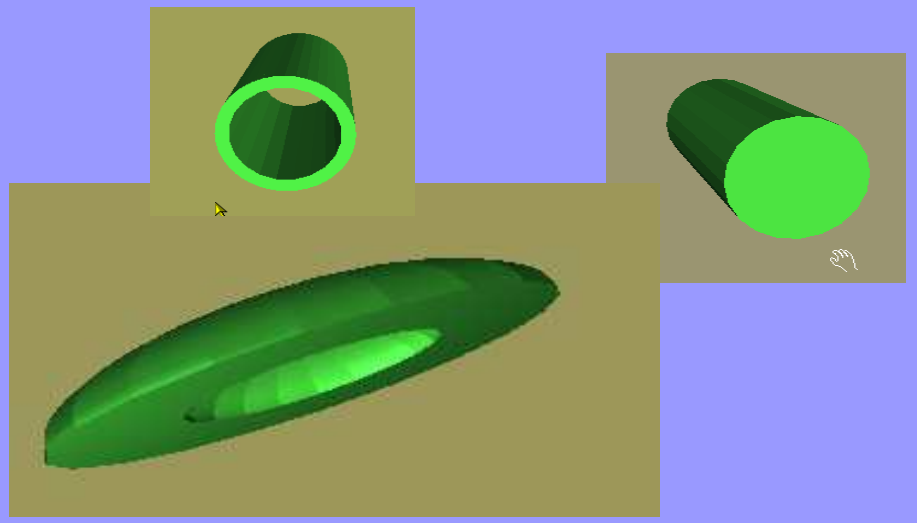
3D Visual Model Building

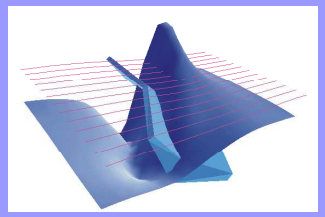


3 primitives
- Prisms
- Polyhedras
- Thin-Sheets

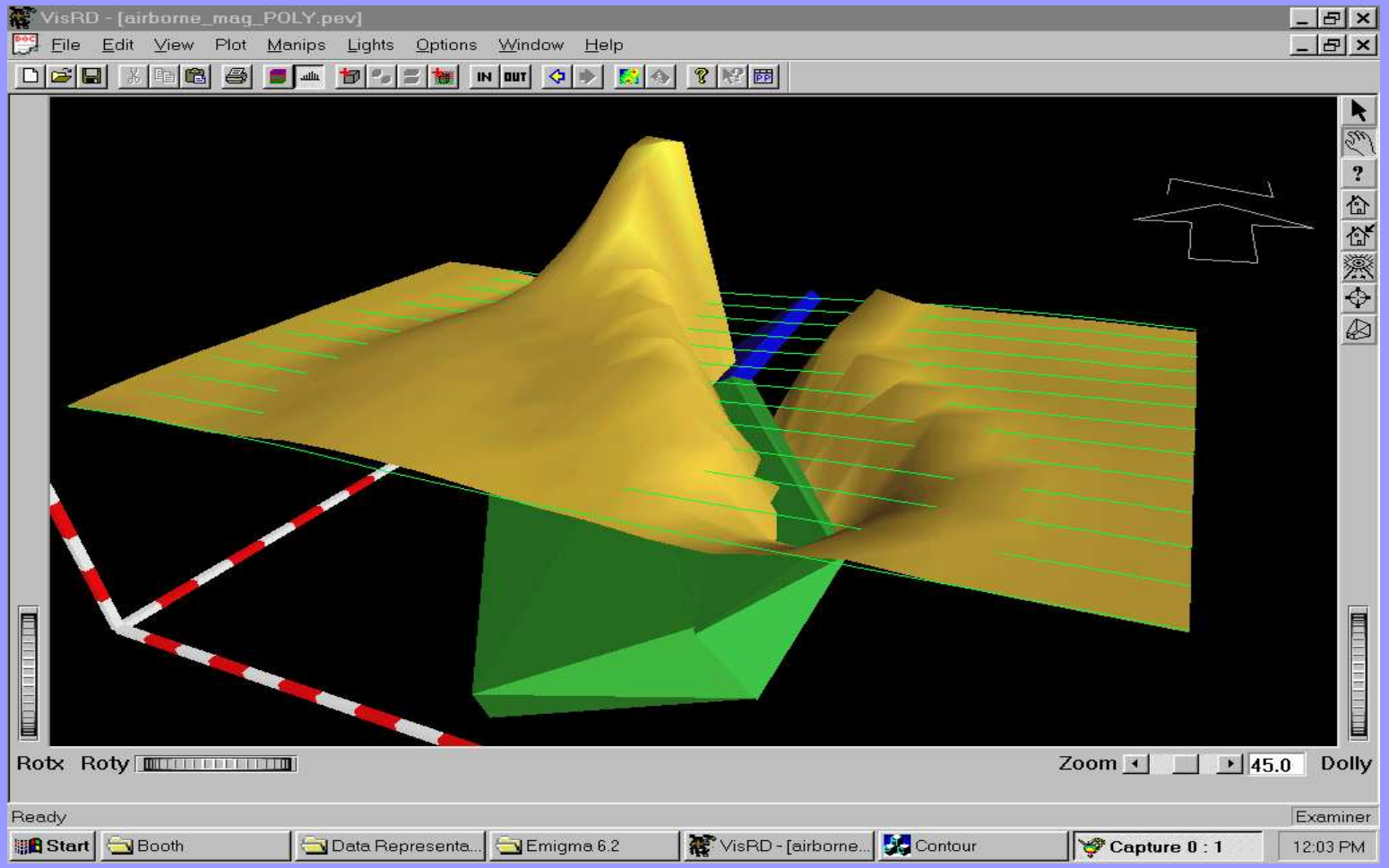








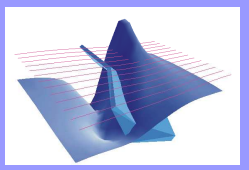
Complex Structure and Data Visualization



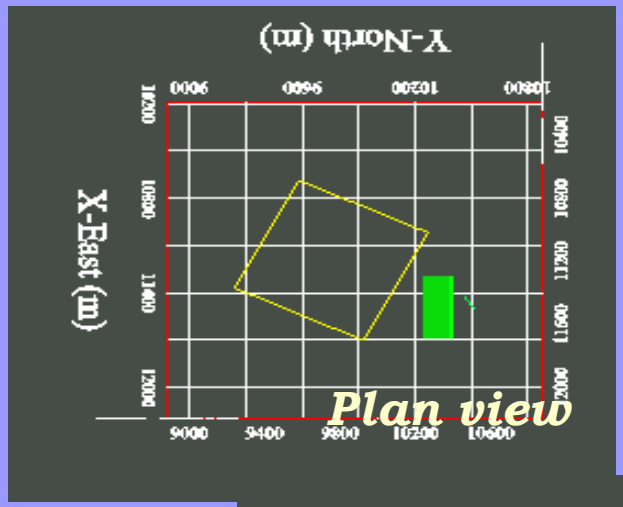
e.g Airborne Magnetic Field Modelling

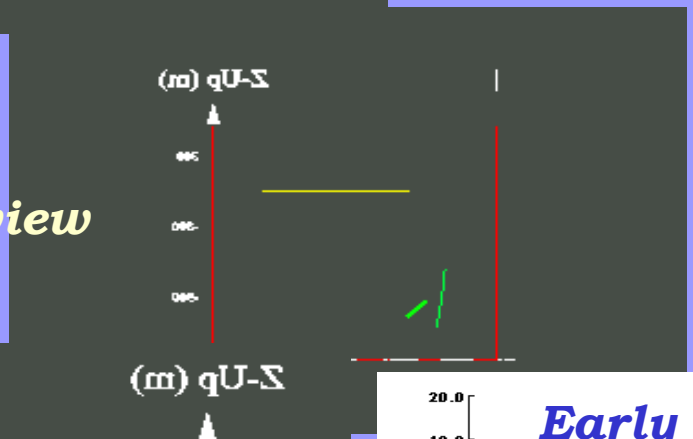
Simulation Calibrations

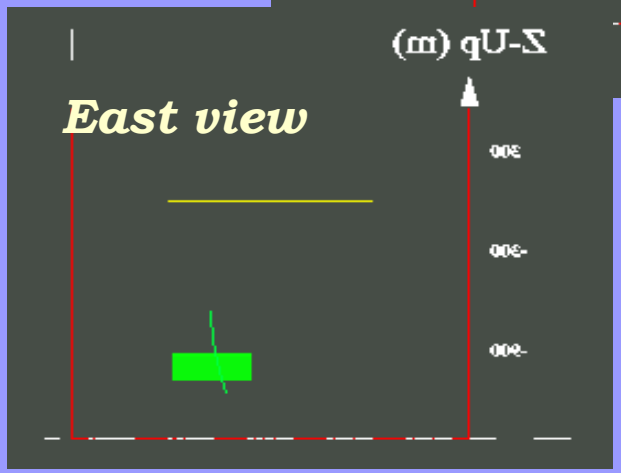
- to other algorithms
- to scale models
- to known geological targets

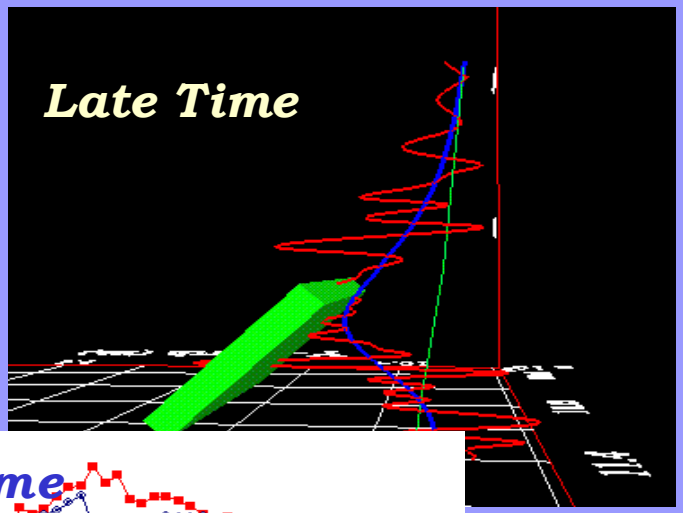


e.g TEM borehole response



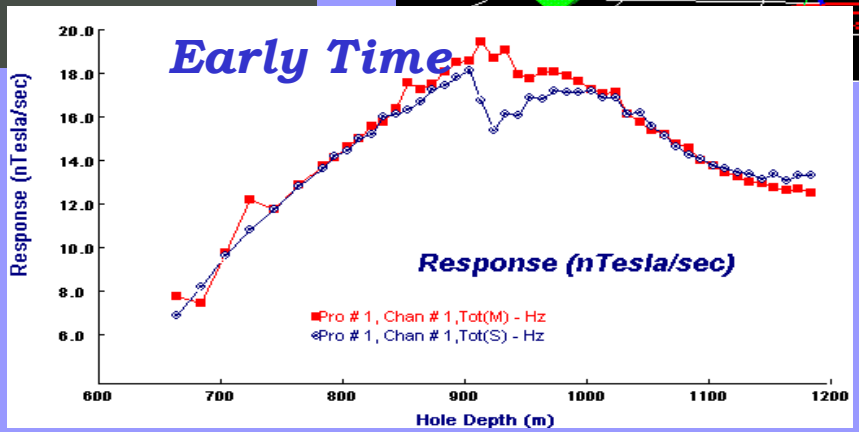


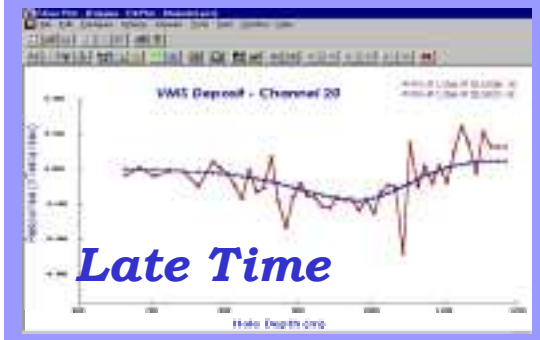




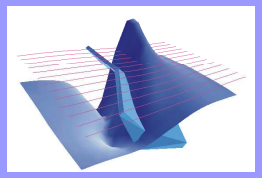
Blue line - simulated

Red line - field data





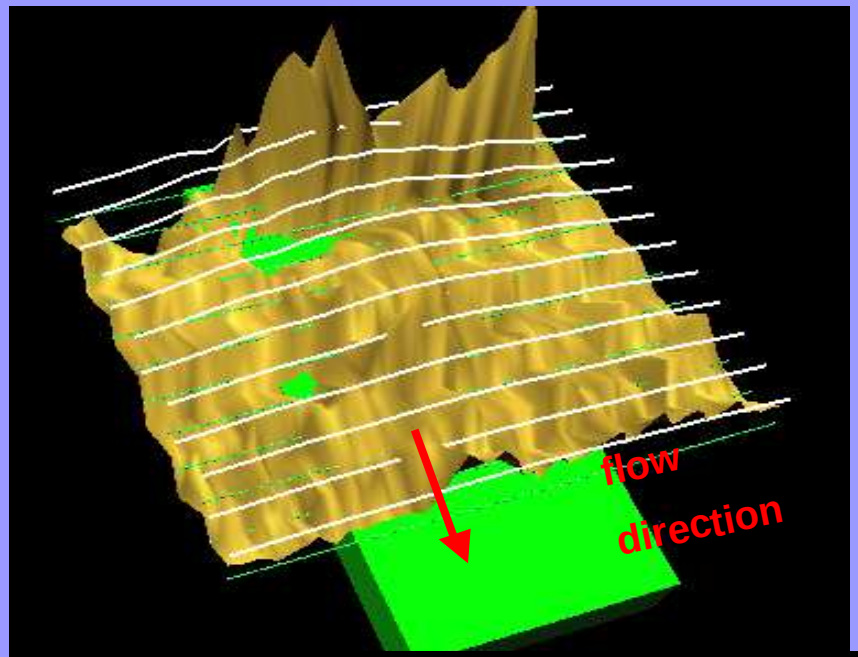
Model and Data Comparison

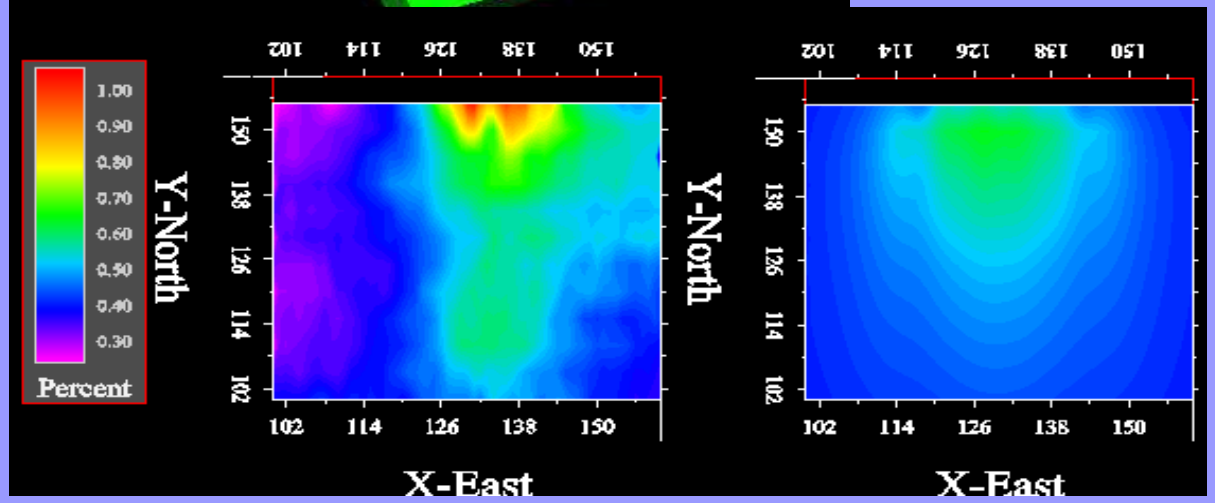


Contaminate Plume - EM31

Canadian landfill site

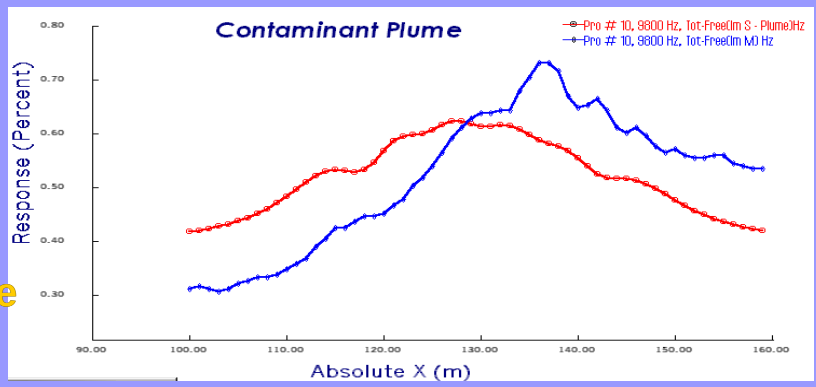
- 3D surfaces
- 2D contours
- 1D plots

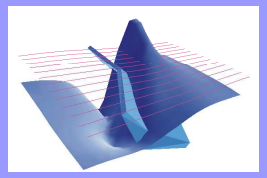




Measured Plume Quadrature response

Simulated Plume Quadrature response



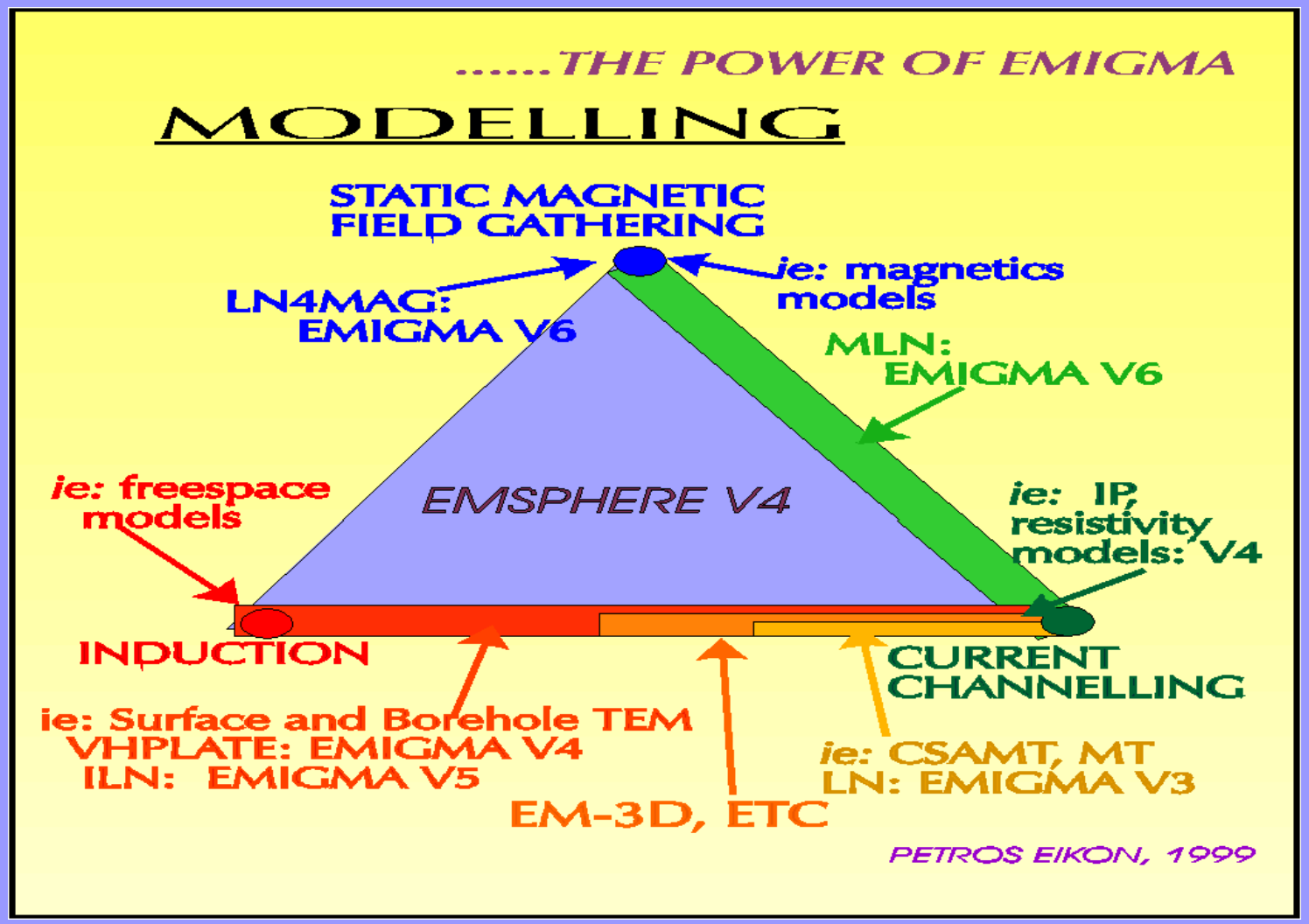


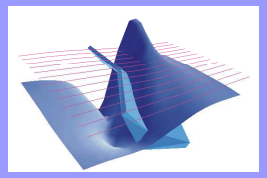
Extensive 3D Modelling Capabilities

6 algorithms
3 model primitives

Resistivity,
Permittivity,
Susceptibility
Contrasts

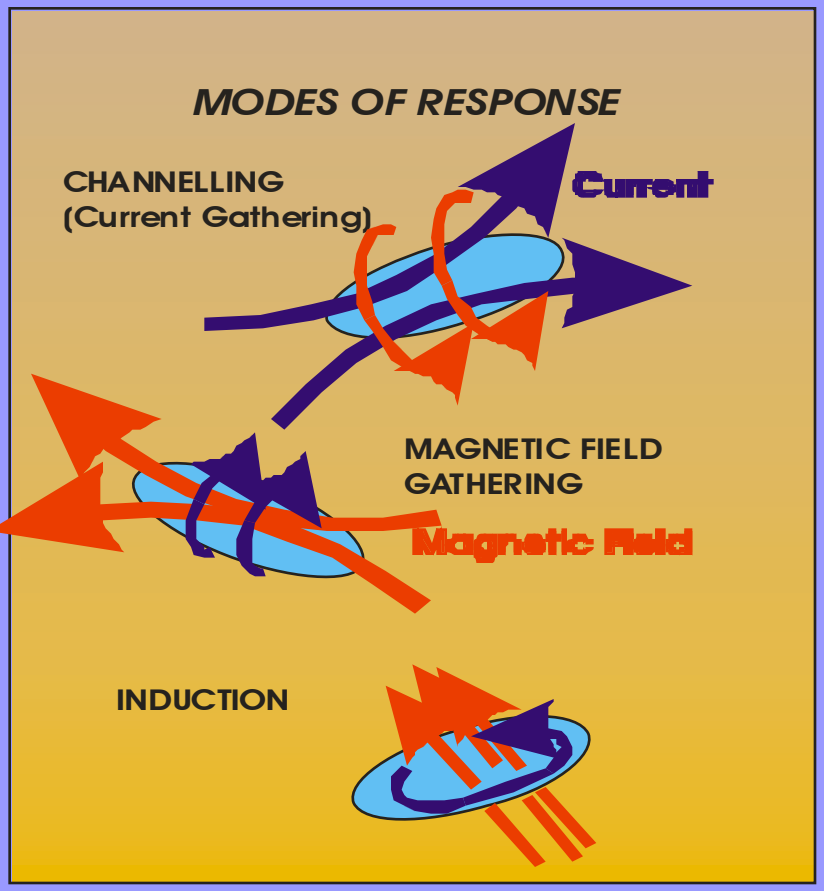
Static
TEM
FEM

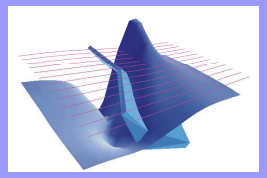




Geophysical Responses

- **EMIGMA Algorithms**
  - **LN (FEM,TEM,IP)**
  - **EiKPlate (FEM,TEM)**
  - **ILN (FEM,TEM)**
  - **MLN (Induced,Permanent)**
  - **3D Gravity (2 methods)**
  - **Born techniques**
  - **3D Resistivity (fast,flexible,accurate)**





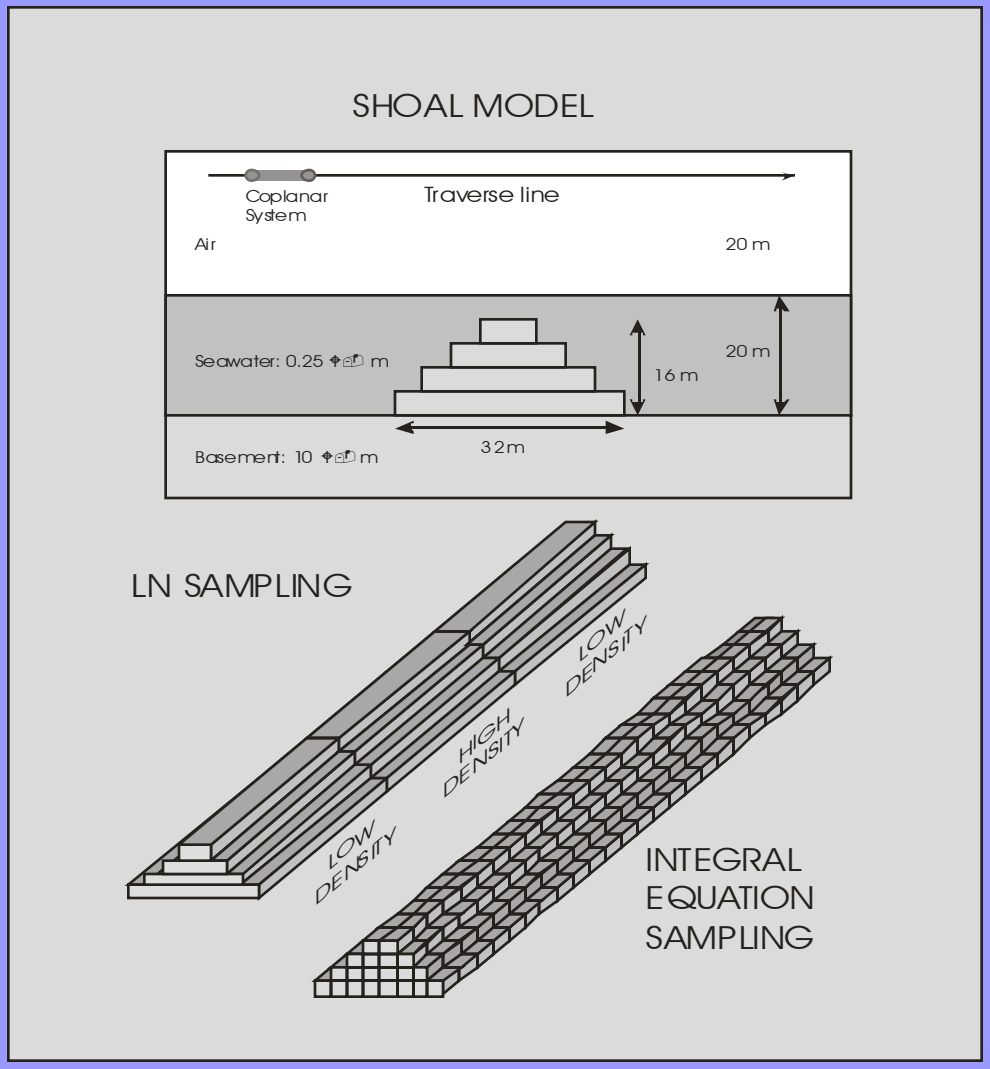
3D Modelling Capabilities 2

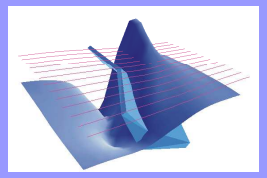
- **EMIGMA Algorithms**
  - **LN**
  - **EiKPlate**
  - **ILN**
  - **MLN**

Rapid Convergence

Flexible and

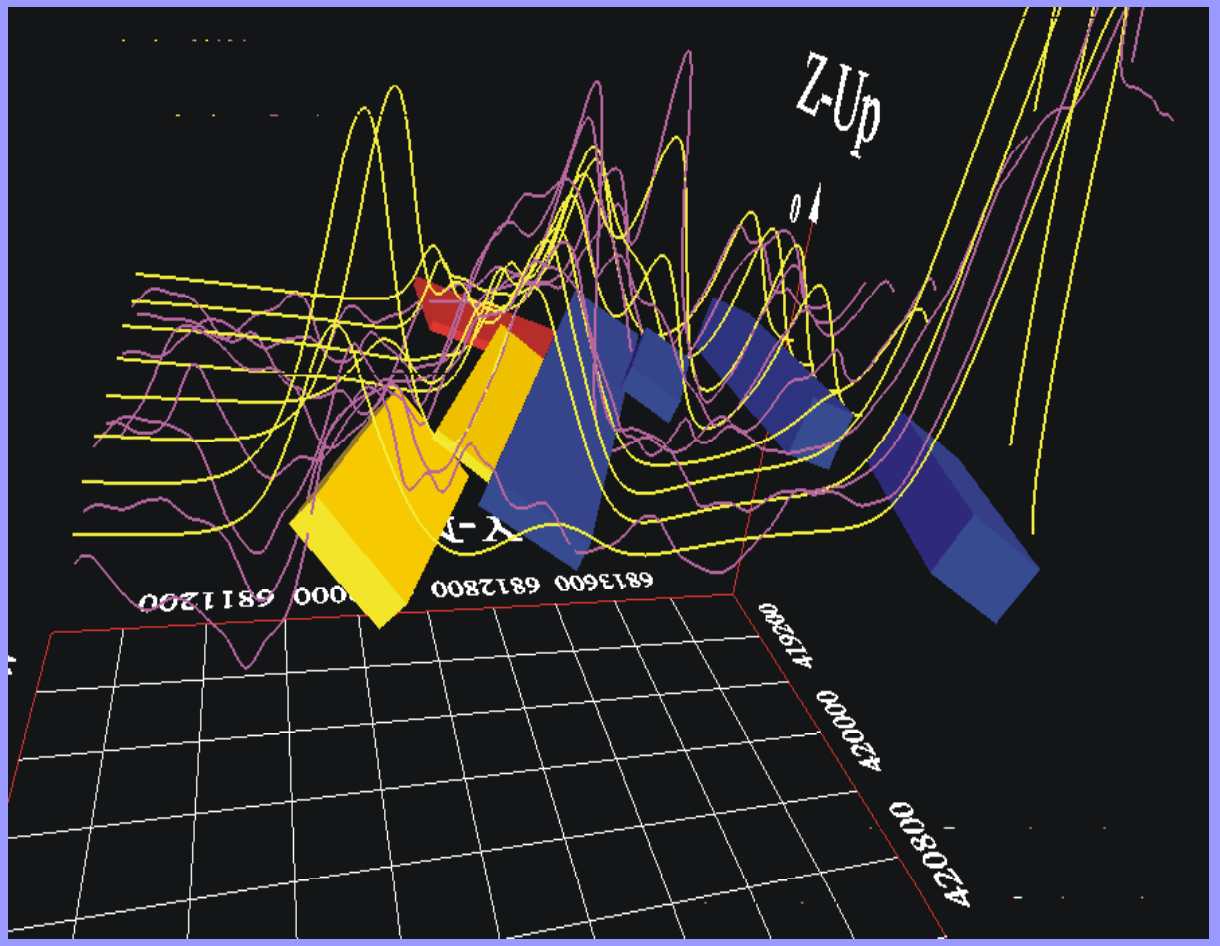
Easy-to-Use Grids





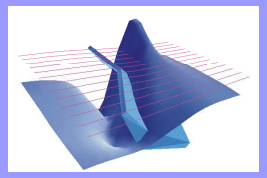
3D Modelling Capabilities 3

Complex Models



Full Range of
Target Interactions

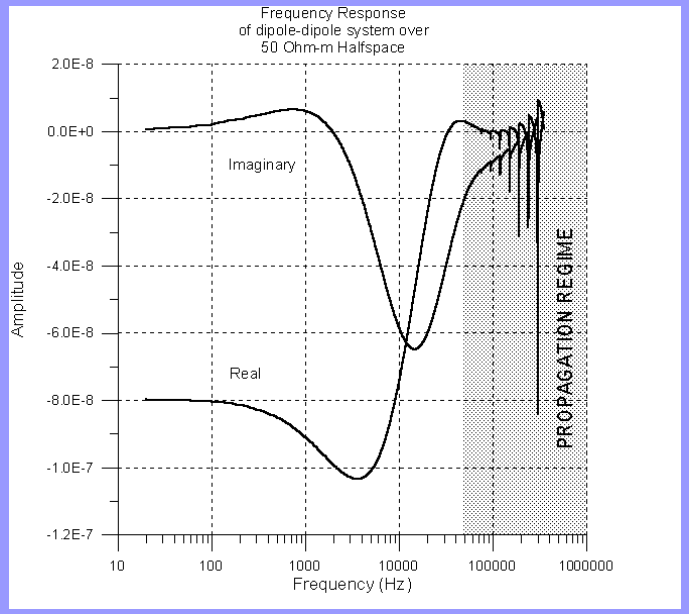
- **Superposition**
- **Near-Field (in contact)**
- **Interaction at a distance**



3D Modelling Capabilities 4

Frequency to Time-Domain Transform

- Why
- How
- Waveforms
- Bandwidth



Typical Magnetic Response

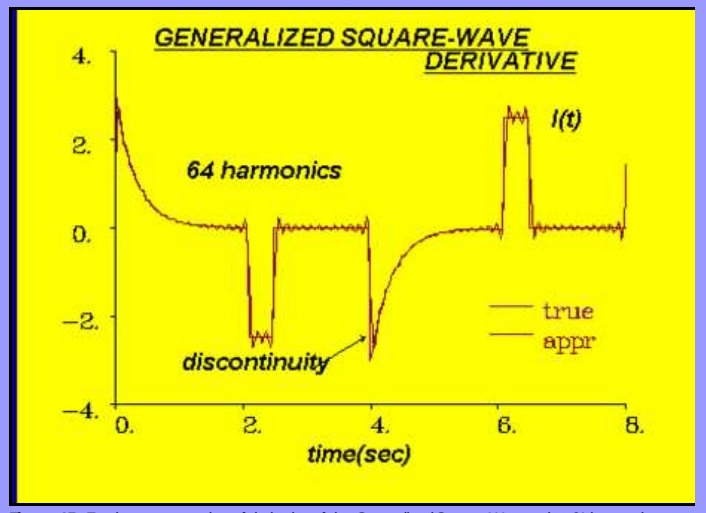
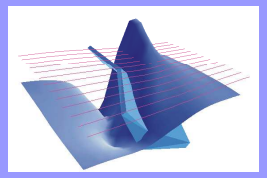


Figure 15: Fourier representation of derivative of the Generalized Square Wave using 64 harmonics.

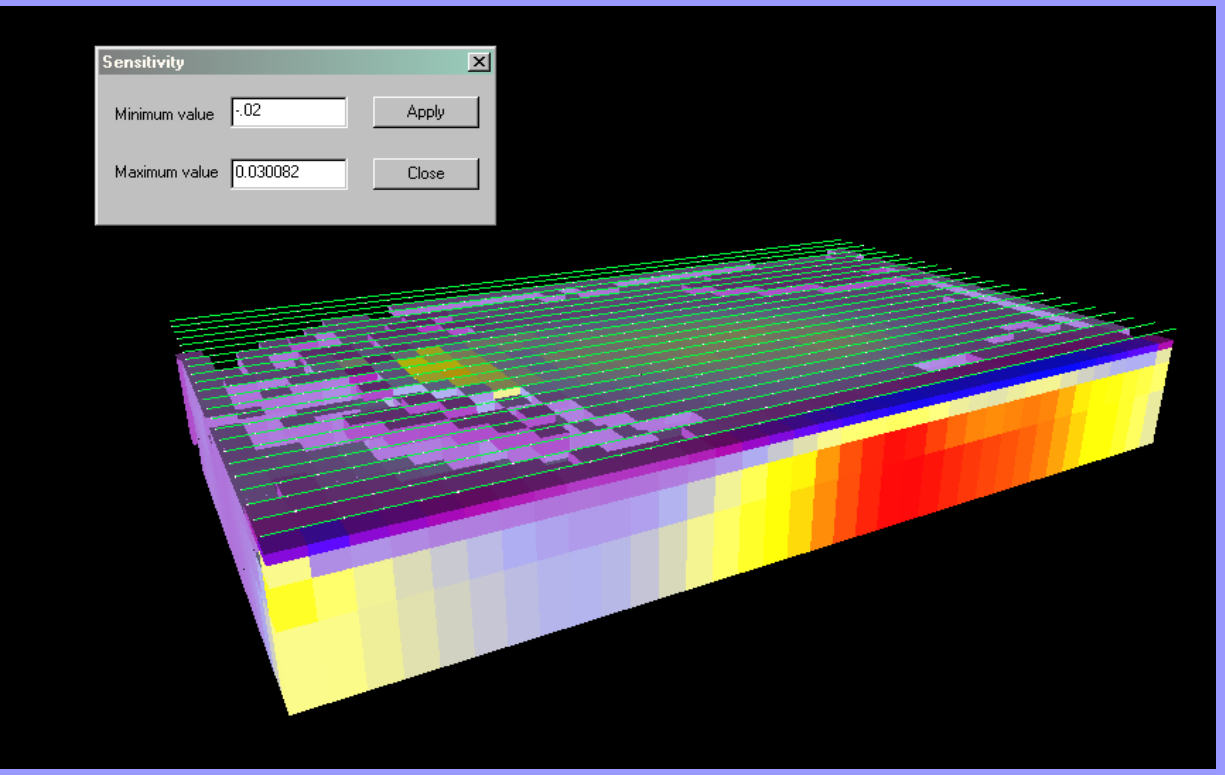
Band limited Coil Response

Incredibly accurate transforms



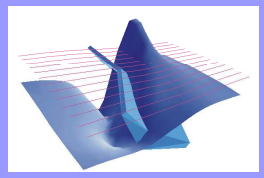
Inversion Capabilities 1

3D Magnetic field Inversion for Susceptibility

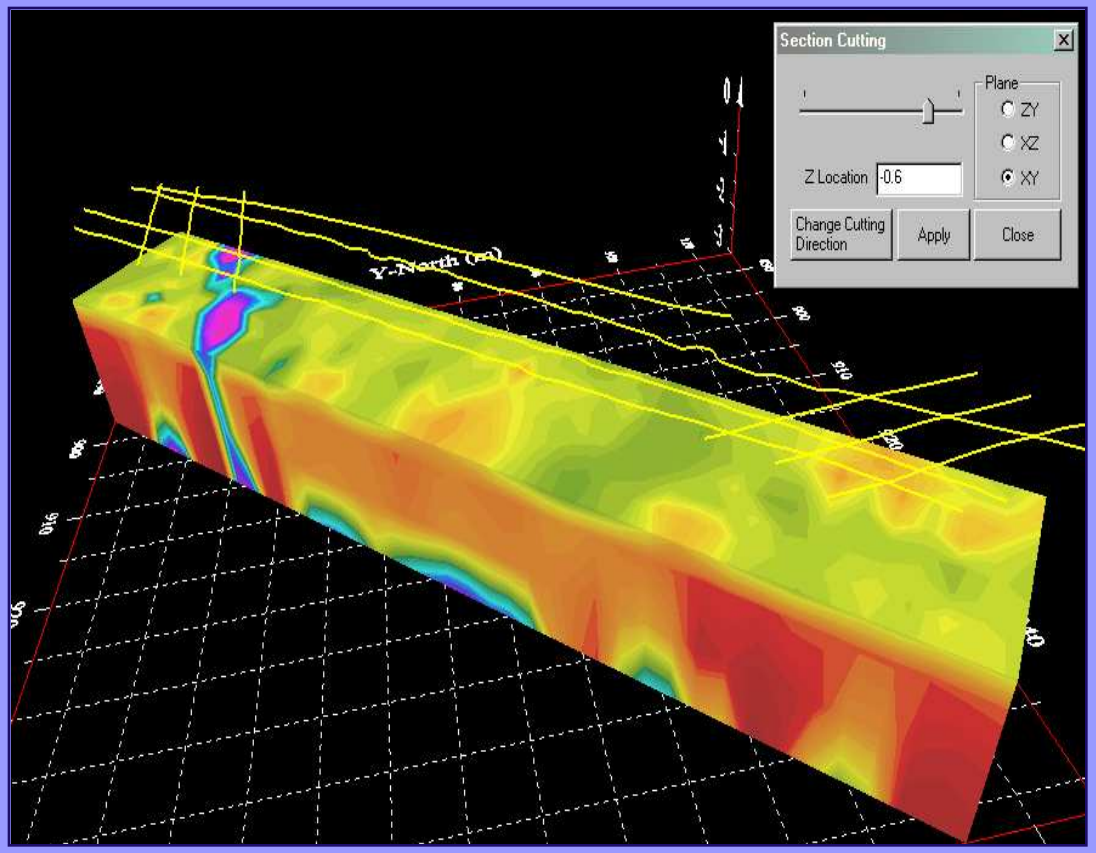


- Multiple levels
- Gradients
- Components
- Matrix
- Optimization
- Linear/ Non-Linear
- Simulation Starting Models
- Strike rotated inversion grids

- Magnetization Vector Inversions
- 3D Euler plus statistical processing



Inversion Capabilities 2



1D Inversion

TEM, FEM and Resistivity

FEM

– ground , HEM, fixed wing

joint resistivity and susceptibility

TEM – multiple base frequency capabilities

- in-loop, out-of-loop

- ground, airborne

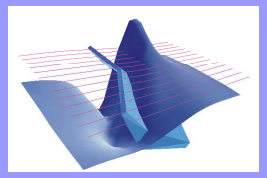
Resistivity: 1D Inverson

Sengpiel Sections:

HEM, Fixed-Wing

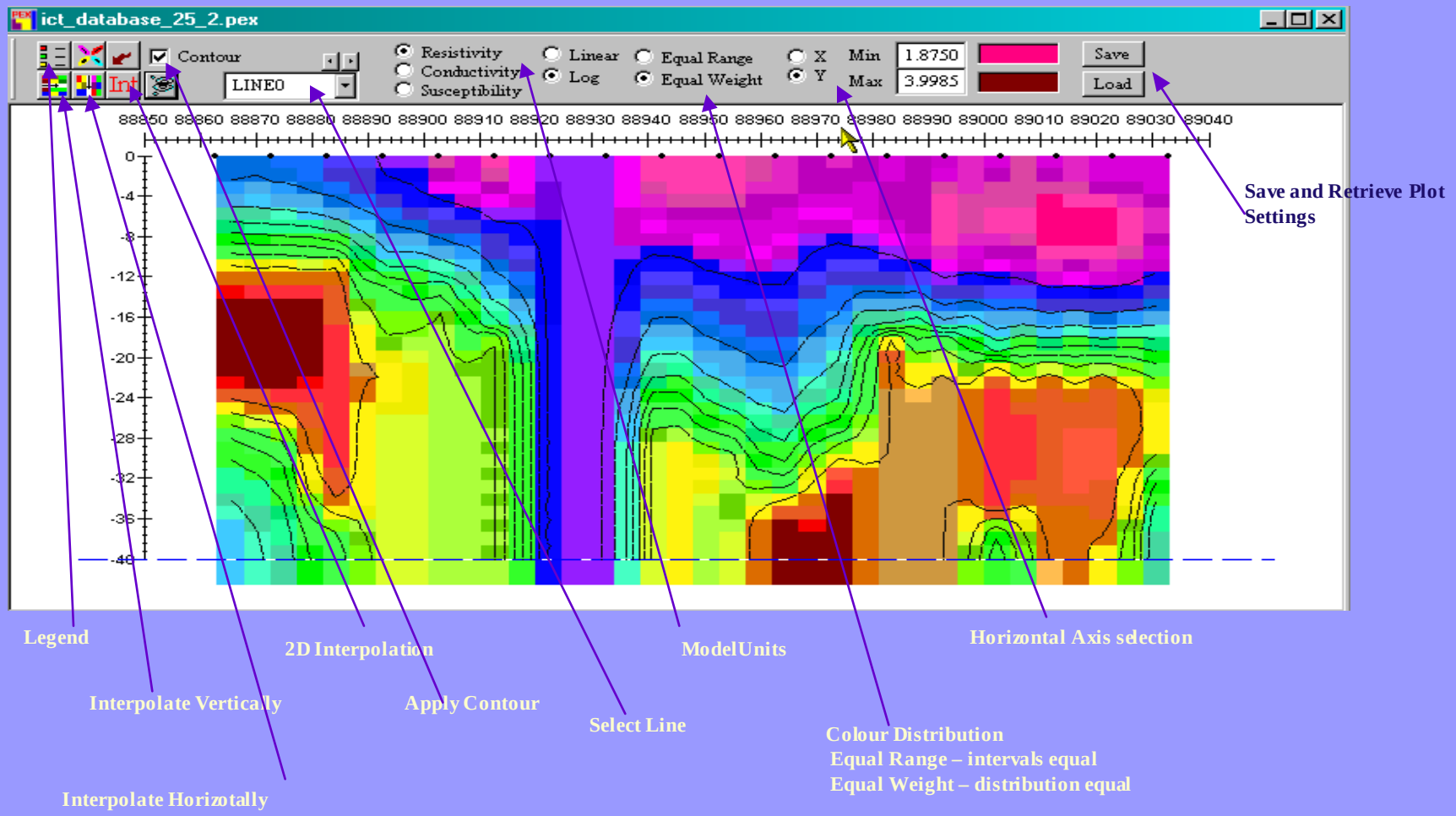
FEM, TEM Apparent Resistivity

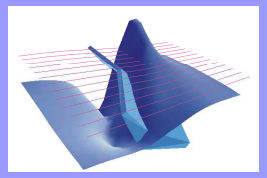
HEM and Ground



Inversion Capabilities 3

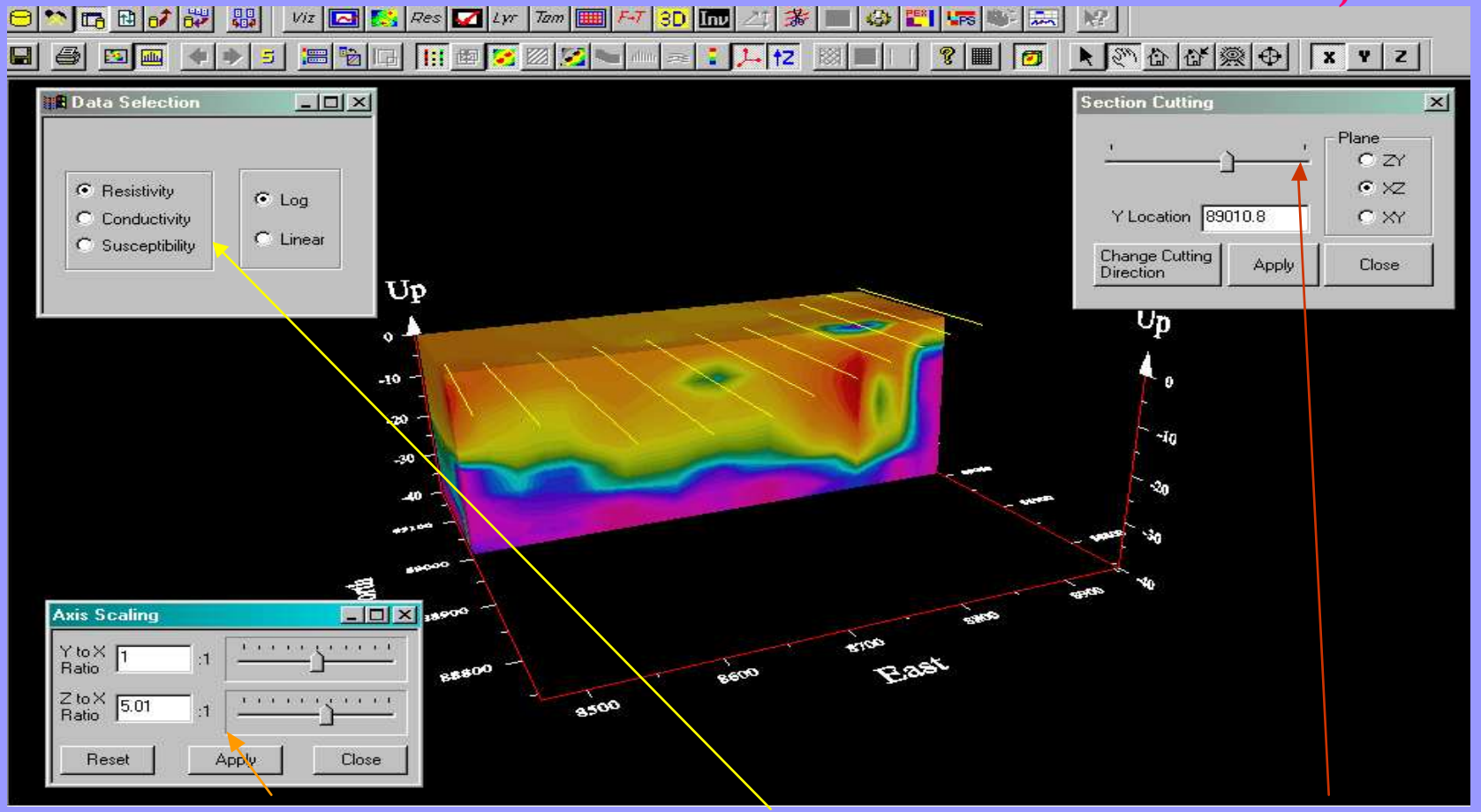
PEX- file Viewer





Inversion Capabilities 4

3D Volume Contour (with Inversion model dataset selected)

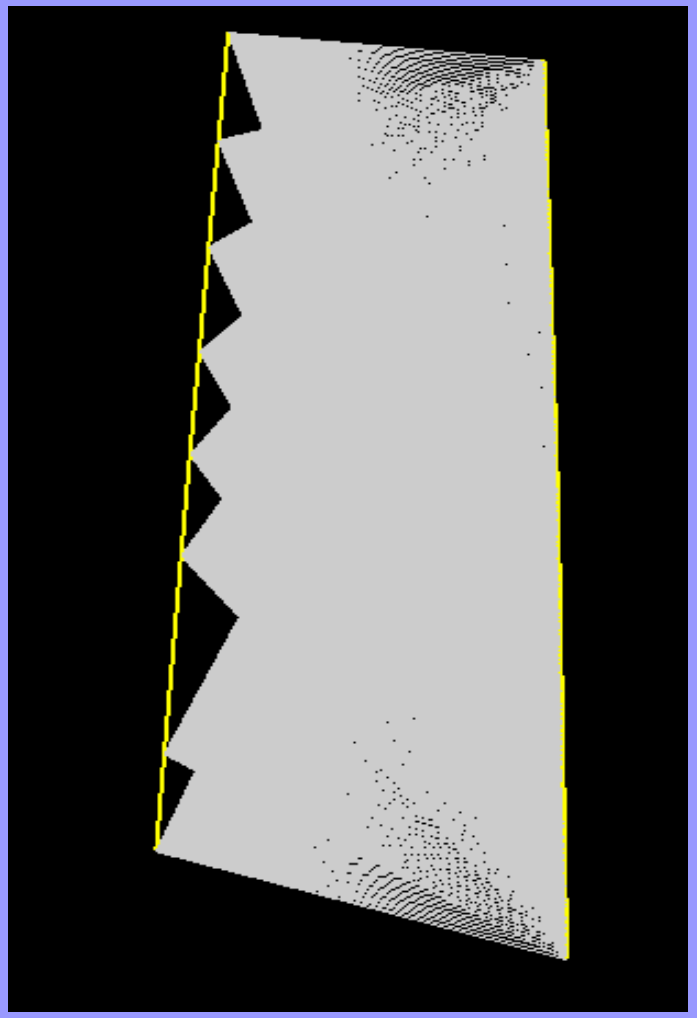


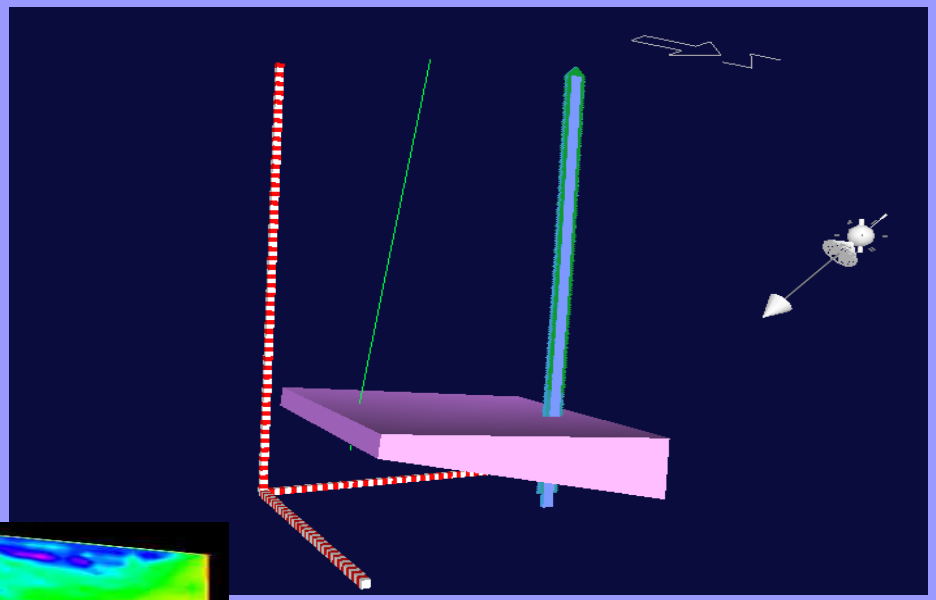
Axis Scaling

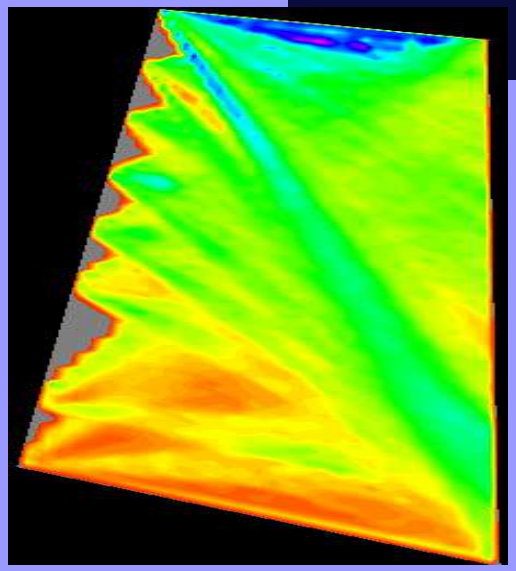
Model Units

Section Cutting

Crosshole Applications







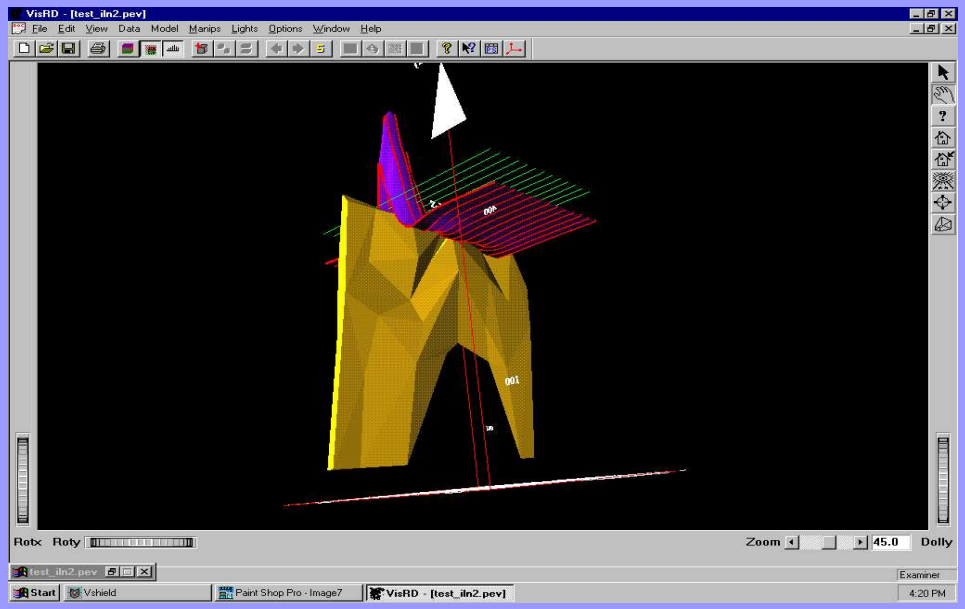
RIM data – lead mine

EMIGMA Training Tools

- Manual in Text Form !
  - *describes all the basic concepts*
  - *technical references*
- Movie Tutorials
- extensive examples
- GeoTutor
- Tutorials as .ppt and .doc formats
- Technical References
- Support - e-mail, voice and fax

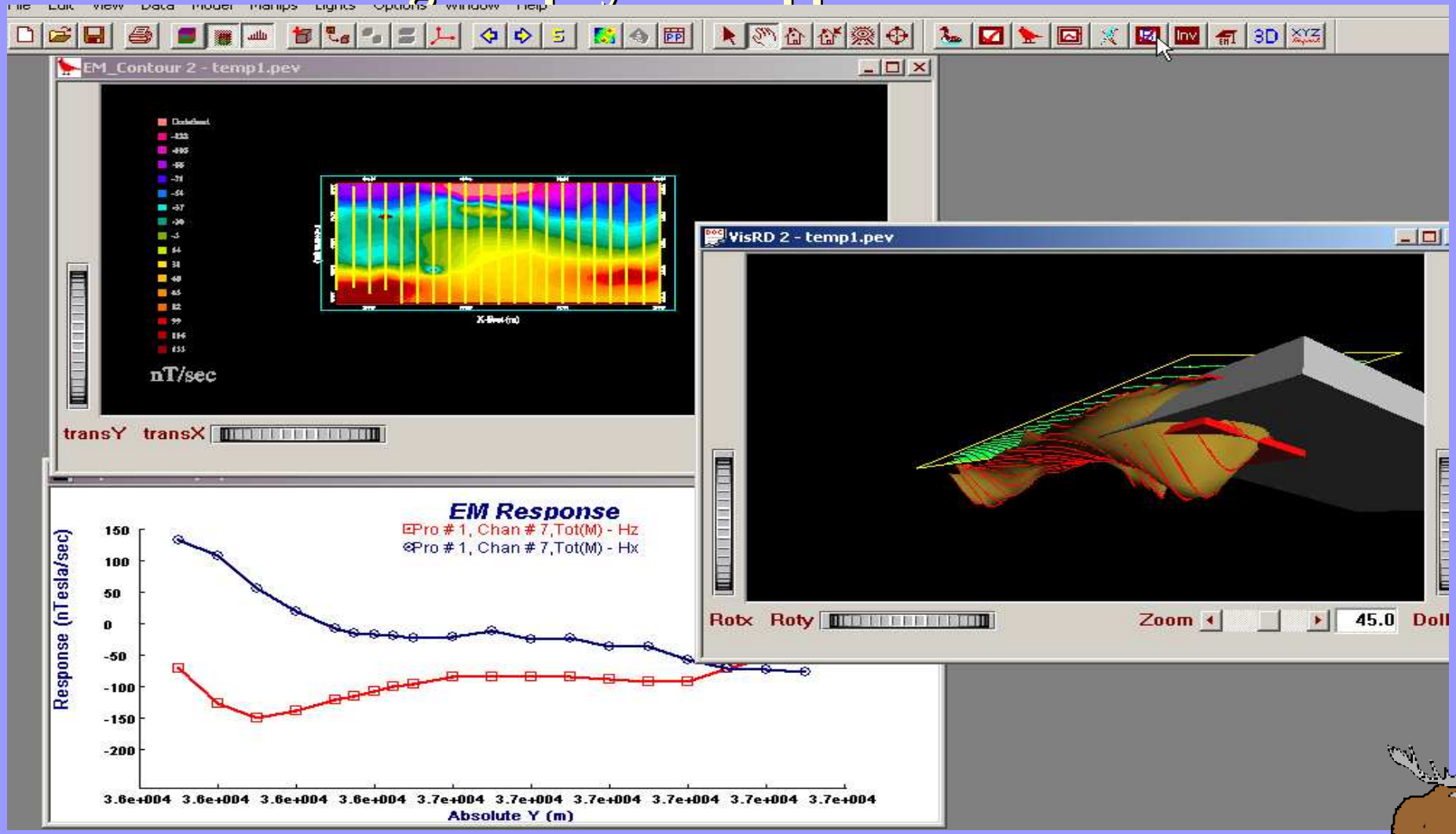
GEOTUTOR

Modelling, Survey Design and Educational Software for Geophysics



PetRos EiKon Inc.

Understanding Geophysical Applications



Modelling and Inversion

Interpretation of Geophysical Data

Applications of GeoTutor

Mining , Oil& Gas, Environmental, Geotechnical

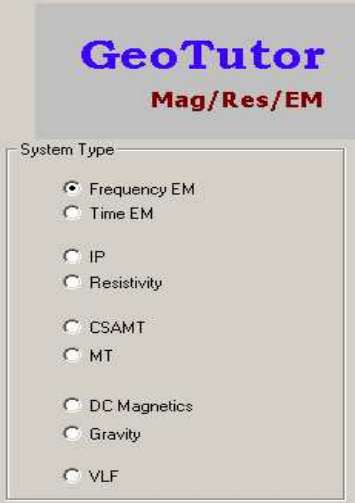
- ***Professional self-instruction***
- ***Survey design***
- ***In-class instruction***
- ***Laboratory courses***

TEM
FEM
MAG
HEM
CSAMT
IP
RESISTIVITY
MT
BOREHOLE
SURFACE
AIRBORNE
CROSSHOLE

- understand geophysical data systems
- geological responses
- geotechnical responses
- survey design

Interpretation of Geophysical Data

GeoTutor training tools



- *Tutor Wizard:*
  - *Step by step system configuration*
- *GeoTutor IV*
  - *Easy-to-use integrated environment*
  - *modelling,*
  - *inversion,*
  - *visualization*
  - *data evaluation*
  - *data plotting*

Geotutor Survey Capabilities

- *Data Types for Modeling*
  - *EM, Resistivity, IP, Magnetics, MT, CSAMT*
  - *Gravity now available*

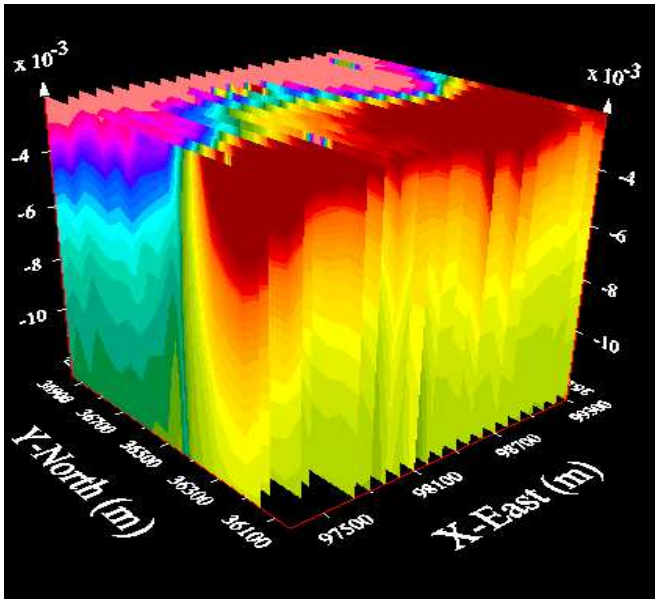
- *Survey Styles*
  - *surface*
  - *airborne*
  - *surface to borehole*
  - *borehole to borehole*

* not all combinations available

Interpretation of Geophysical Data

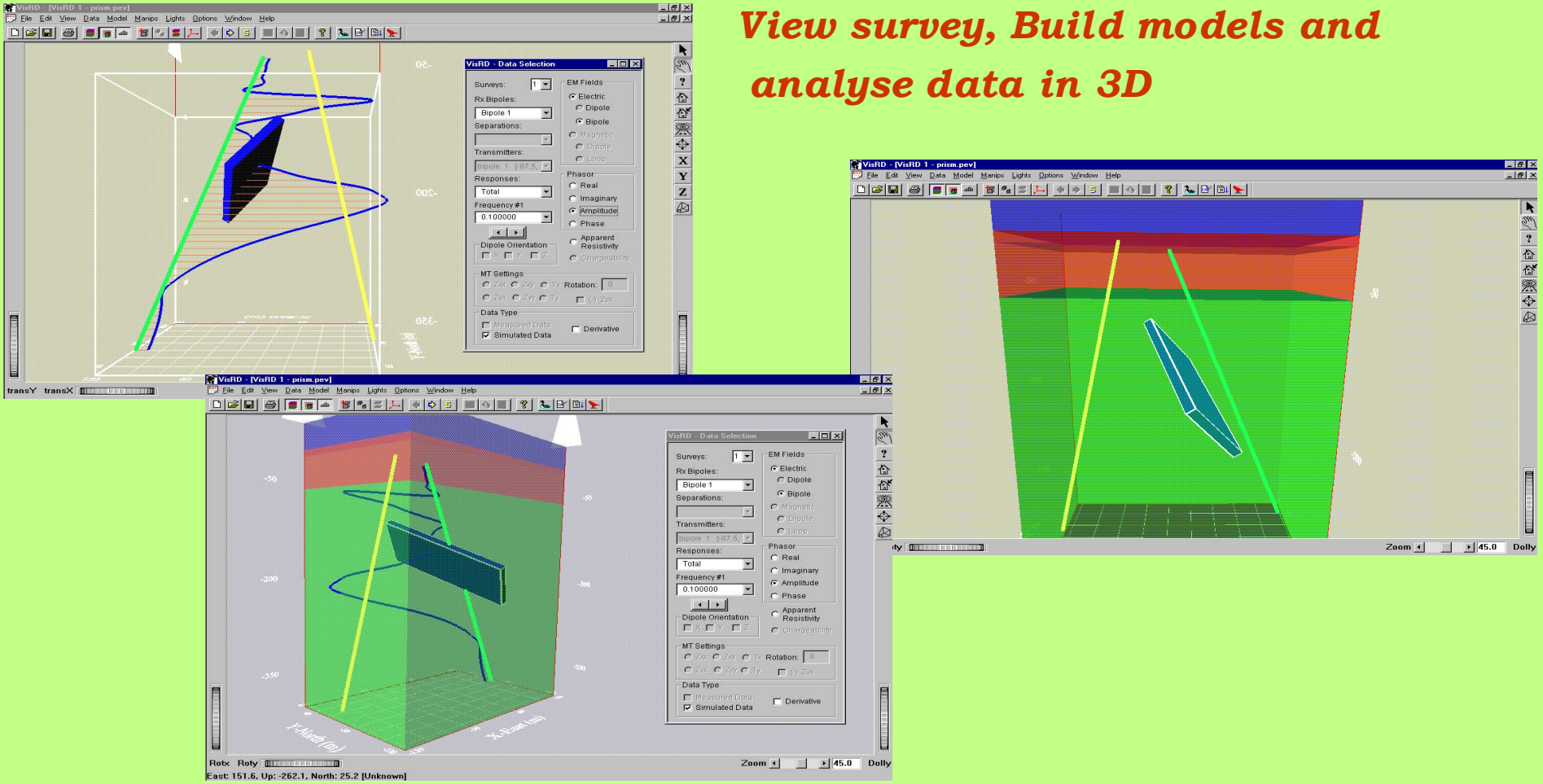
GeoTutor Capabilities

- 3D Forward Modelling
- 3D Visualization
- 3D Model Building
- 3D Magnetic Inversion
- 1D,2D and 3D Data Displays
- 1D FEM Inversion
- Synthetic MT and CSAMT 1D Inversion
- FEM, MT and CSAMT
  Pseudo-Depth Geoelectric Sections
- Contouring

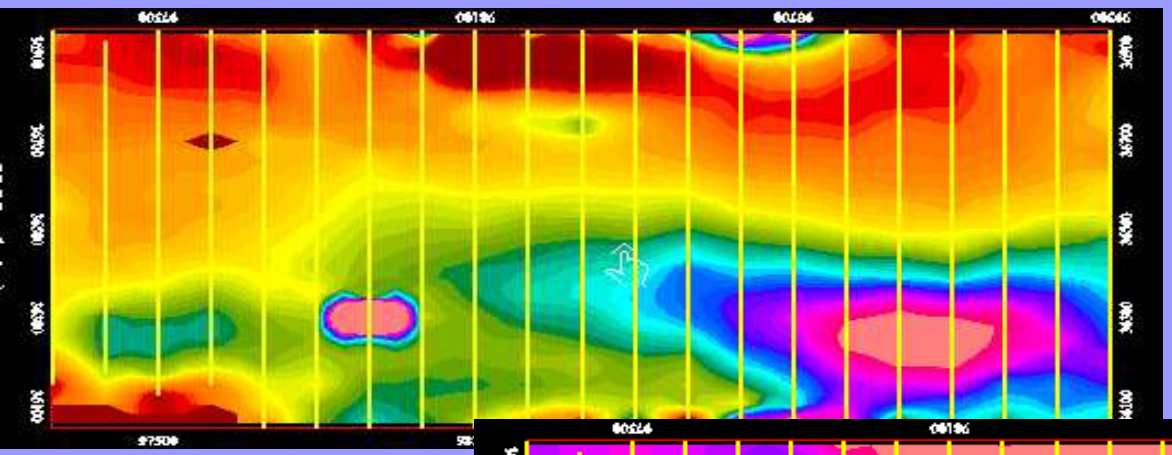


Model Building and Simulation

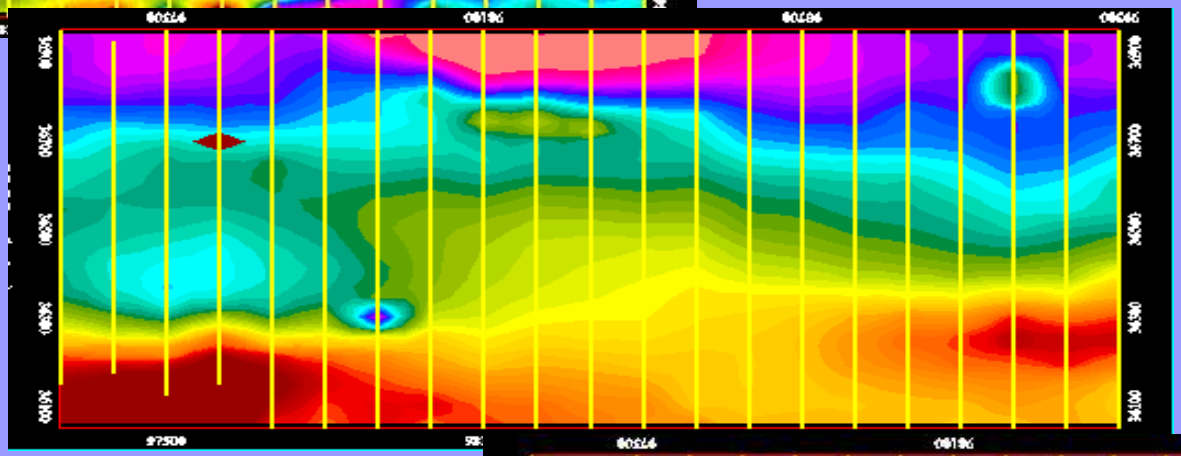
View survey, Build models and analyse data in 3D



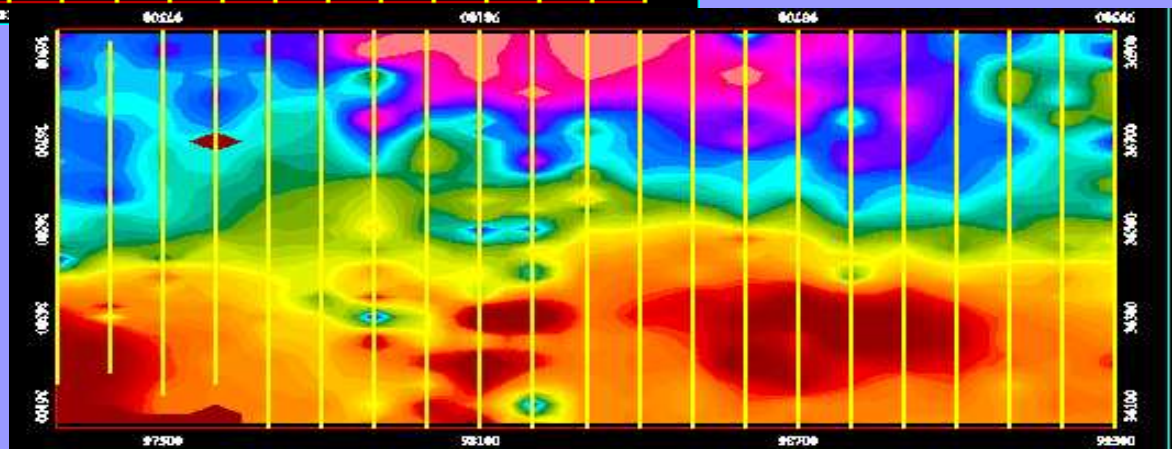
Quasi Animation



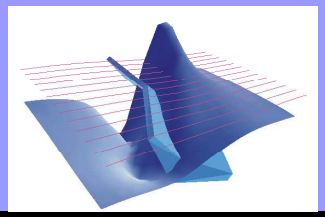
Early-Time TEM data



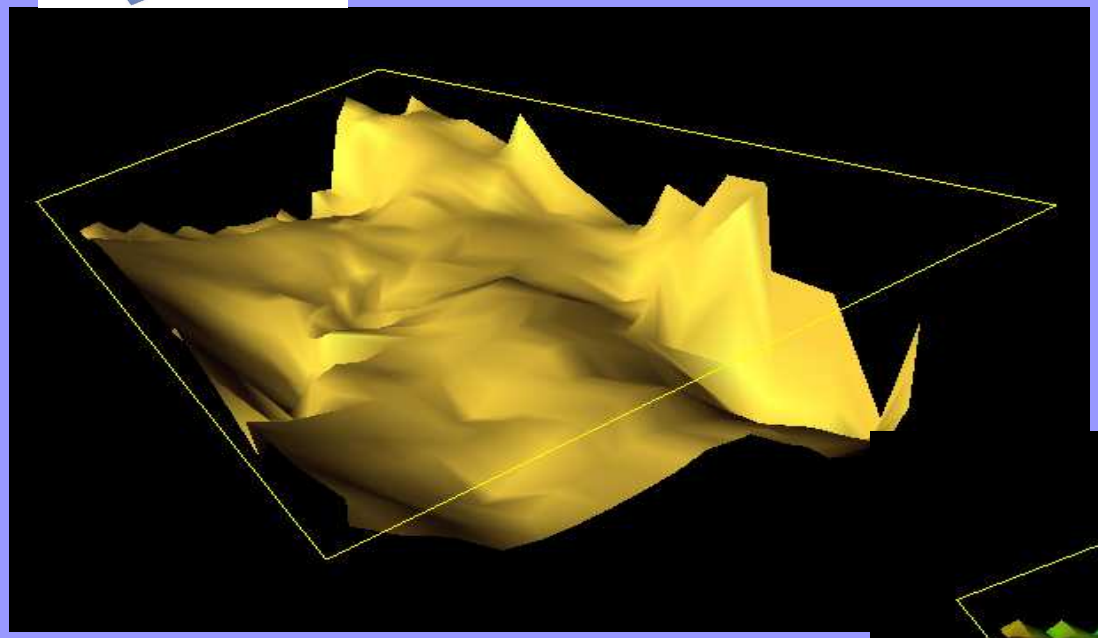
Mid-Time TEM data



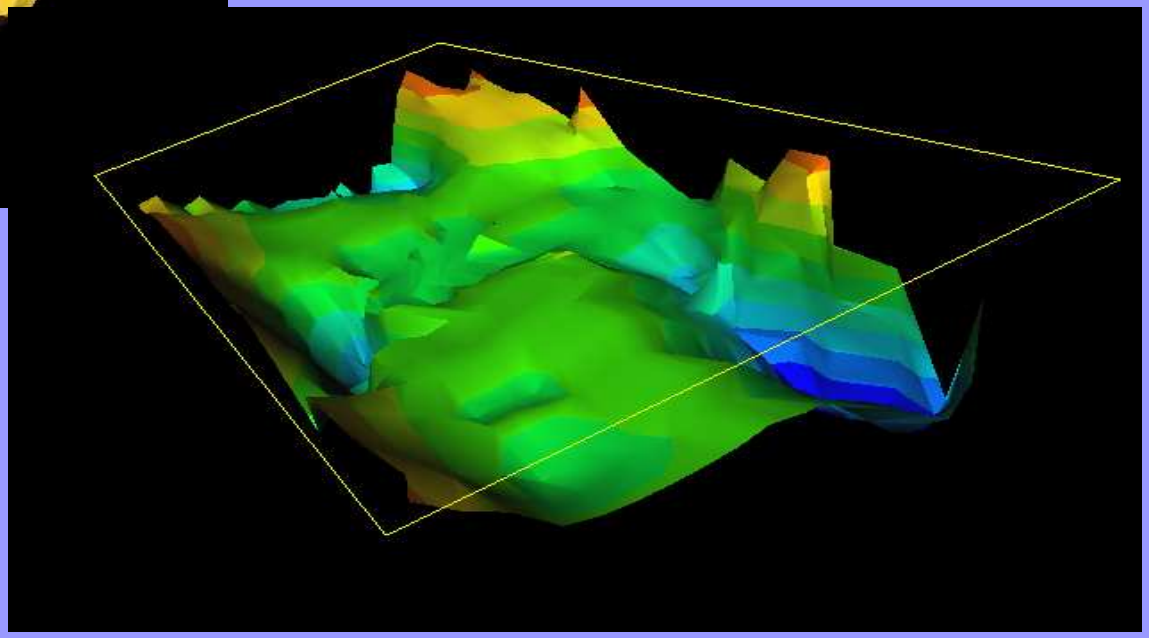
Late-Time TEM data



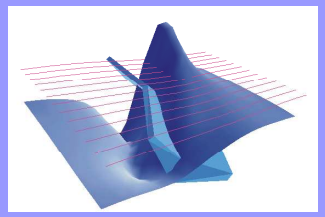
Surface representation of data allows for a spatial display of anomalies



Data Surface

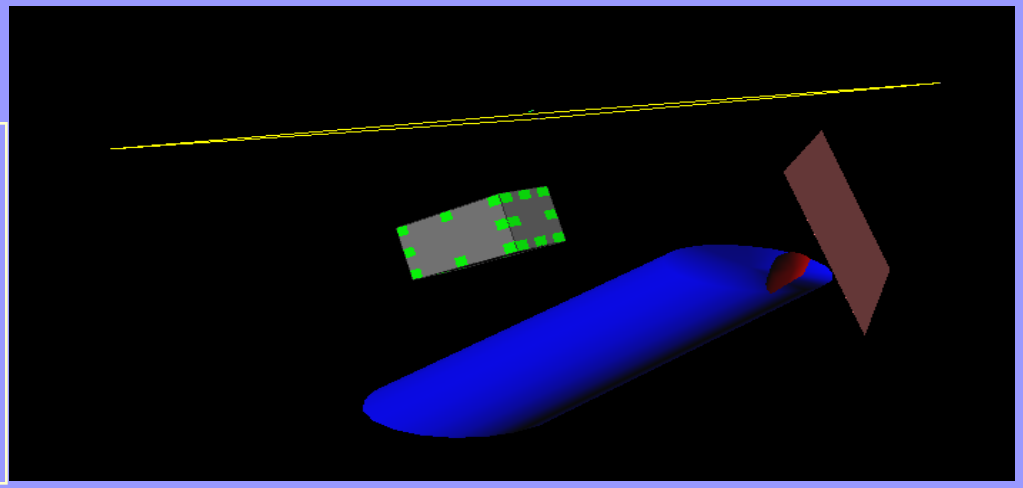


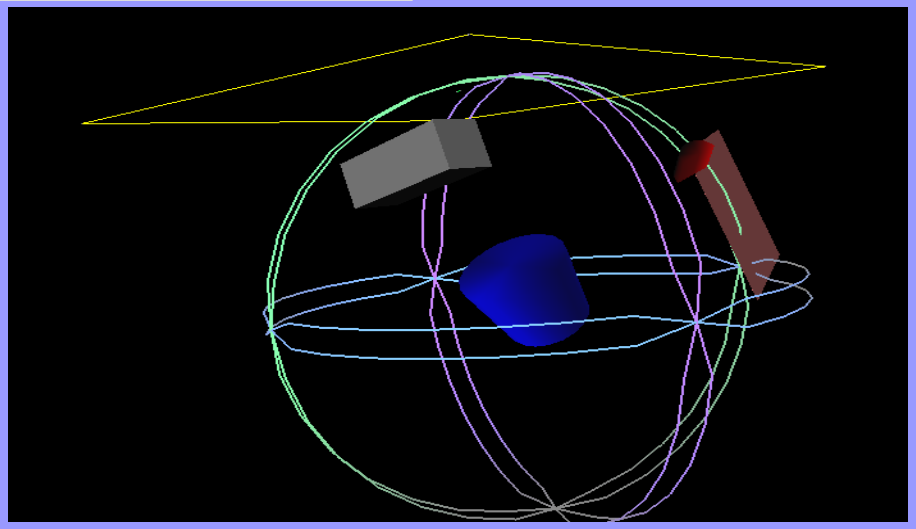
Contoured Data Surface

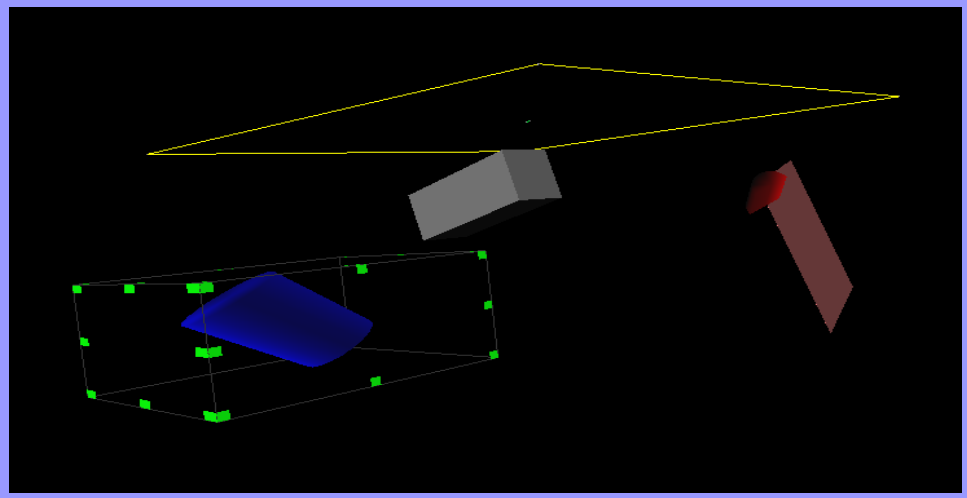


3D Visual Model Building

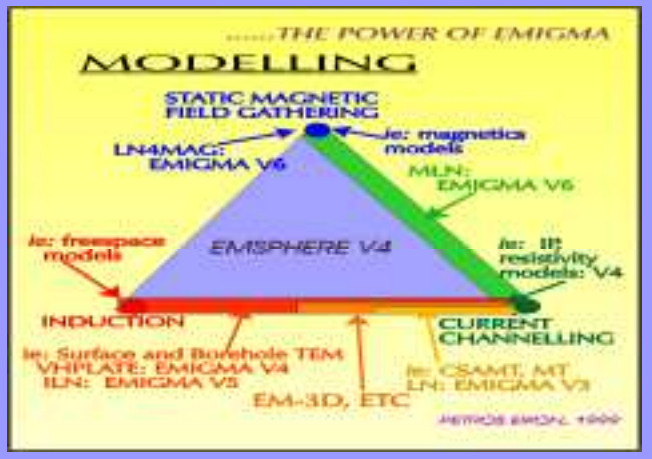
4 primitives
- **Prisms**
- **Polyhedras**
- **Thin-Sheets**
- **spheres**







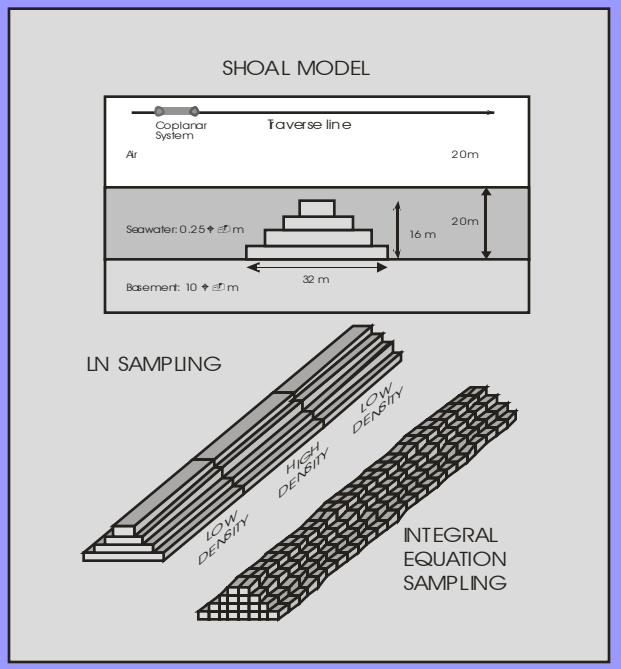
Extensive 3D Modelling Capabilities



6 algorithms

4 model primitives

- Resistivity/Conductivity
- Electrical Permittivity
- Magnetic Susceptibility
- Density
- Cole-Cole
- Permanent Magnetization



Static (DC)

Time Domain

Frequency Domain

Flexible and Easy-to-Use Grids

Geotutor Training Tools

- Manual in Text Form
  - *describes all the basic concepts*
  - *technical references*
- Movie Tutorials
- extensive examples
- Tutor Wizard
- Tutorials already in powerpoint format

- Rapid Support - e-mail , online support