PetRos EiKon

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

EMIGMA V7.5

Sophisticated software
for the practicing Geoscientist
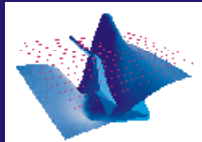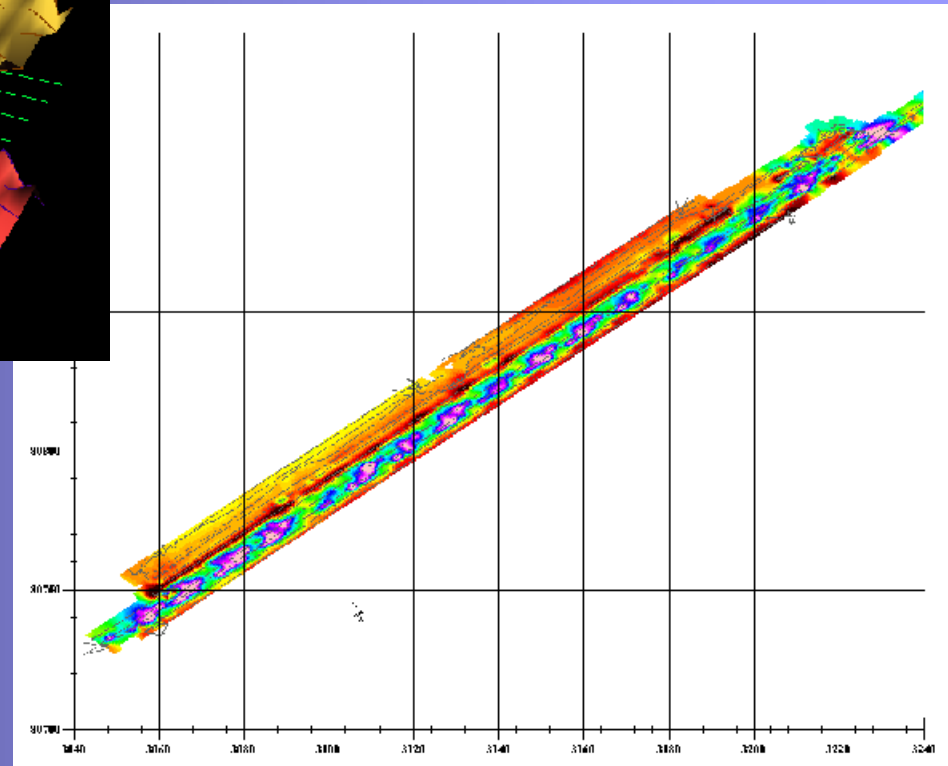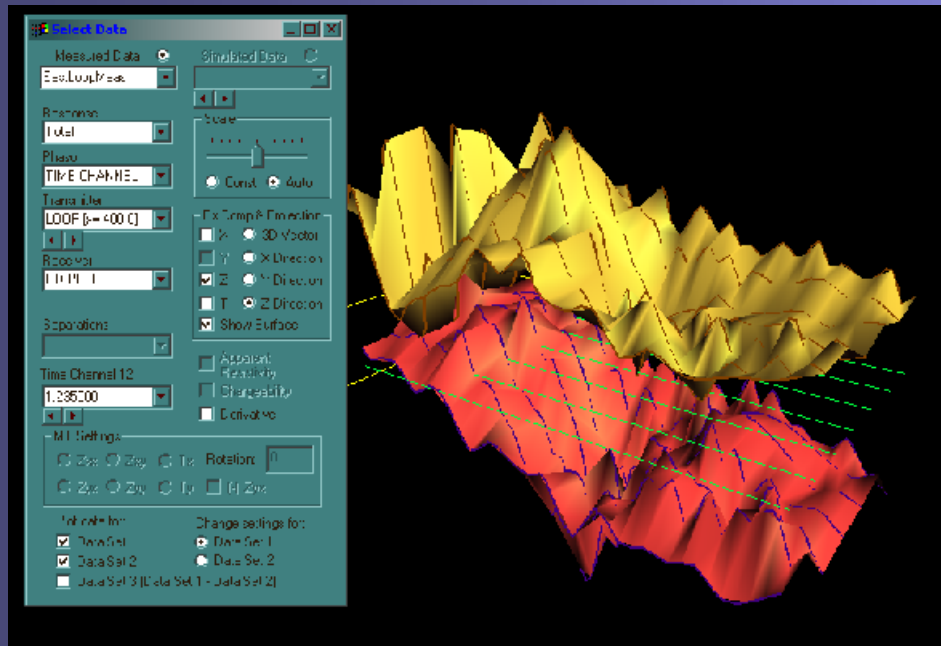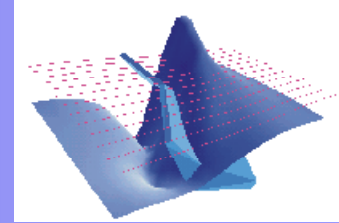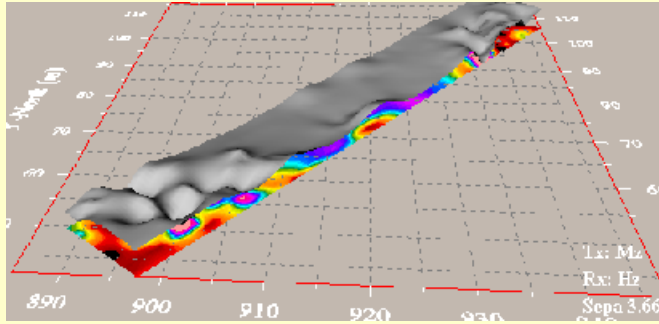
QCtool

GEOTUTOR
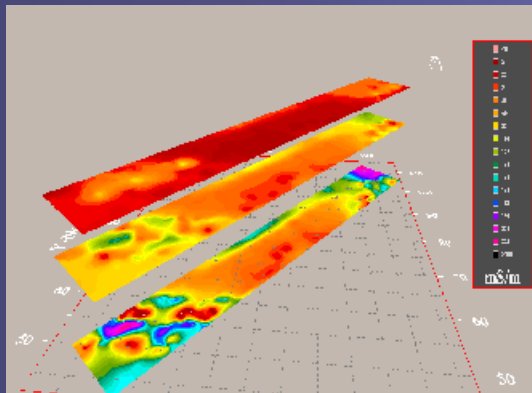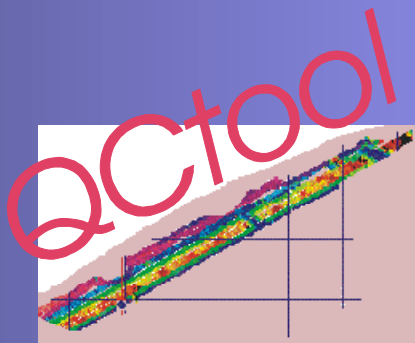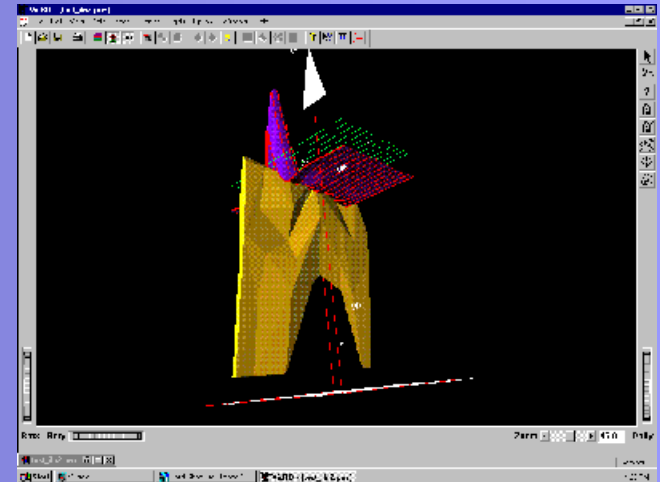
Since 1994, Developers of Software for Interpretation of Geophysical Data

Modelling, Inversion and Data Analyses

Applications

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

⬀ detect, delineate

⬀ depth determination, spatial resolution

⬀ survey design

⬀ characterisation, evaluation

PetRos EiKon products
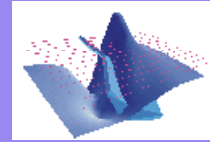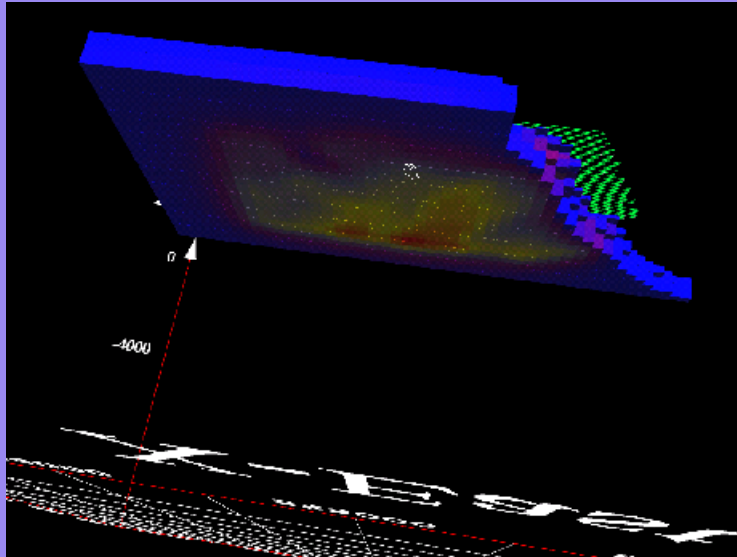
EMIGMA V7.8
Database application
Data editing , filtering, and analyses
Contouring and Visualization
Data Simulation and inversion
Gridding and grid tools
Raster map registration, projections
Potential field FFT processing
Aeromagnetic compensation

GeoTutor III
Educational and training purposes
Modelling, Inversion,
Visualization
File-based
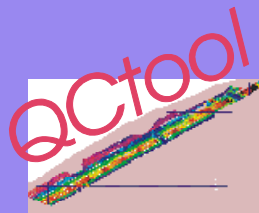
QCTool
Data evaluation
Data plotting and gridding
Data editing, spreadsheet, filtering
Binary "database" file

Mining – (majors,juniors,consultants,universities)
- ✓ *Since 1994*
- ✓ *Detection, Delineation, Survey Design*
- ✓ *Airborne, Surface and Borehole*
- ✓ *EM, Magnetics, IP*

Near-Surface – (consultants, governments, universities)
- ✓ *Since 1998*
- ✓ *data evaluation, gridding, and presentation*
- ✓ *Inversion and Modelling*
- ✓ *FEM, TEM and Magnetics*
- ✓ *UXO, Groundwater, Geotechnical, Archeological*

Academics – (40 universities worldwide)
- ✓ *Since 1995*
- ✓ *Teaching and Research*
- ✓ *Environmental, UXO, mining, Oil and Gas*
- ✓ *EM, Magnetics, Gravity*
- ✓ *Modelling, Inversion, Survey Design*

Oil and Gas – (consultants)
- ✓ *Since 2000*
- ✓ *Airborne magnetics and EM, gravity*
- ✓ *Survey Design, Processing, Geological modelling*
- ✓ *Airborne, Surface and Borehole*

EMIGMA Survey Capabilities

Design Aim:

All non-seismic data surveysfrom DC to 5 MHz!

- ♦ *Data Types*
  - ◢ *EM, Resistivity, IP, Magnetics, CSAMT*
  - ◢ *Gravity*

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

* not all combinations available

EMIGMA Tools

EMIGMA V7.5

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)*
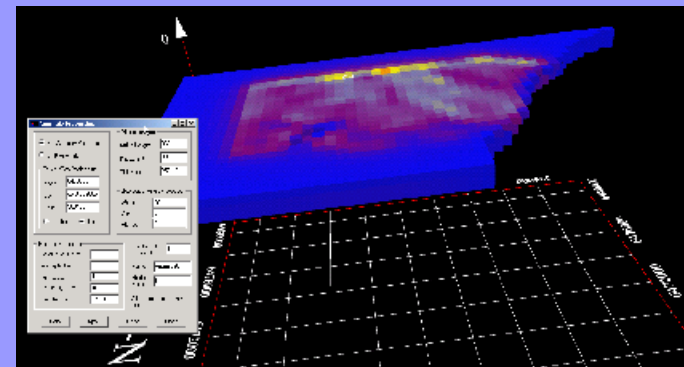
EMIGMA Tools

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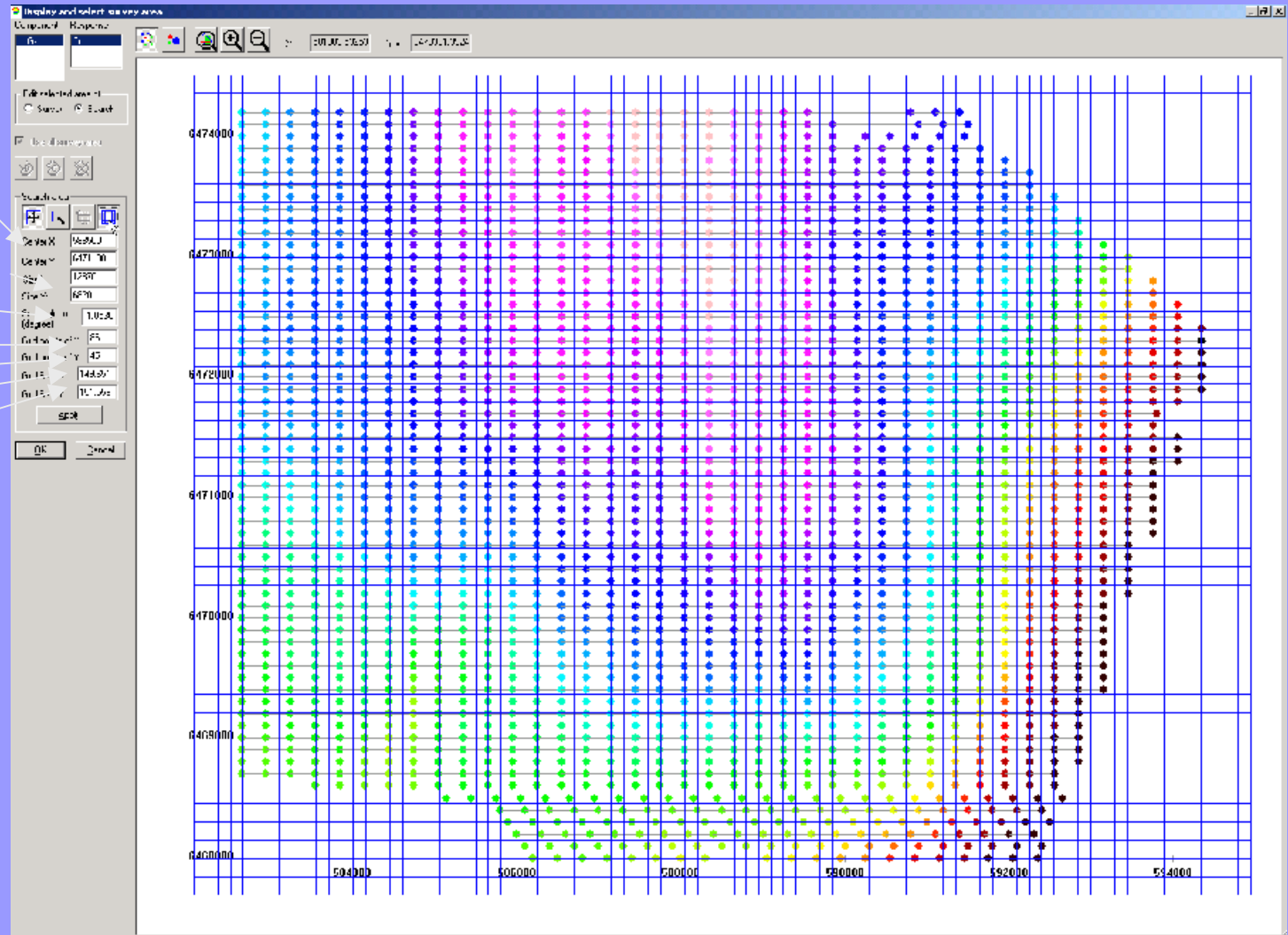
centre of XY-grid

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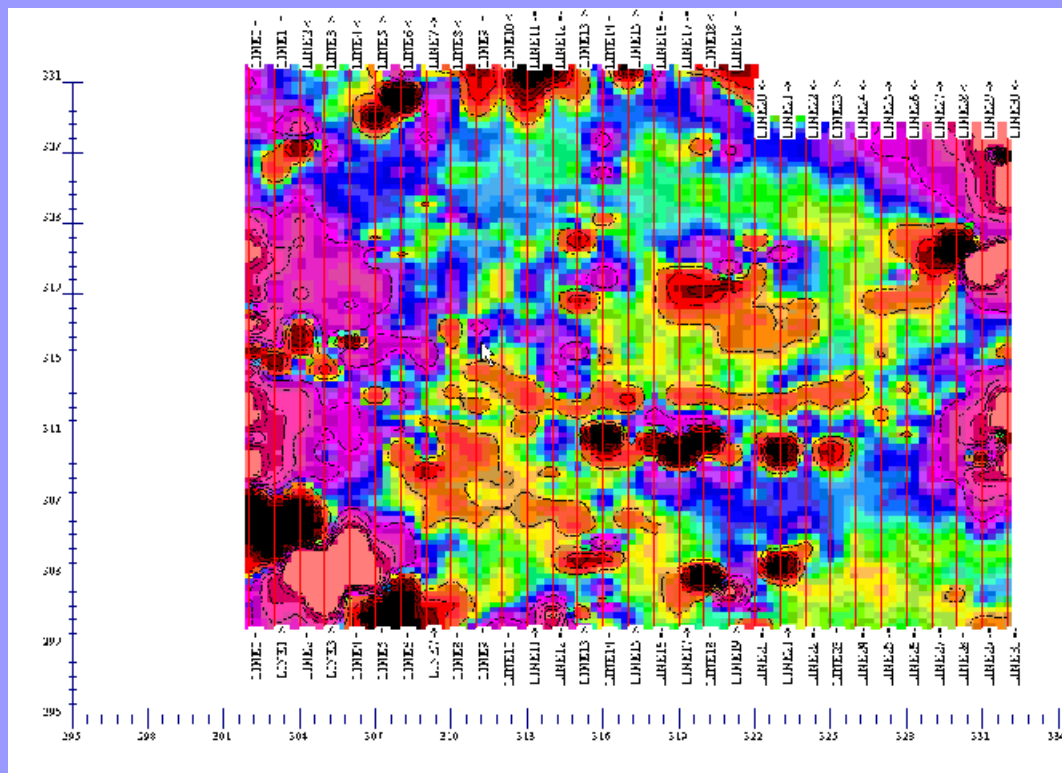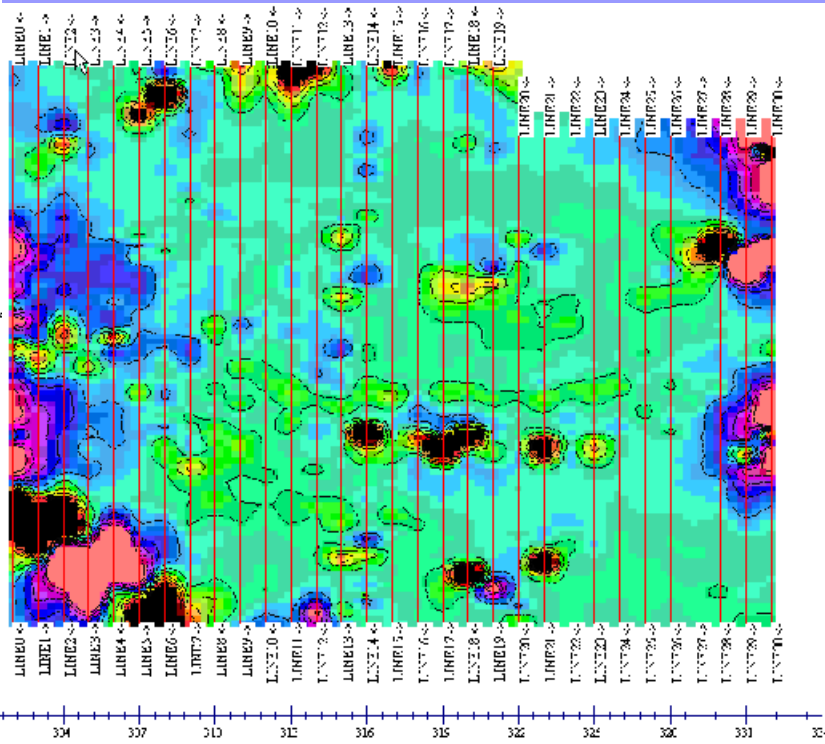**dY in grid**

EMIGMA ©

Data Interpolation and Contouring 1

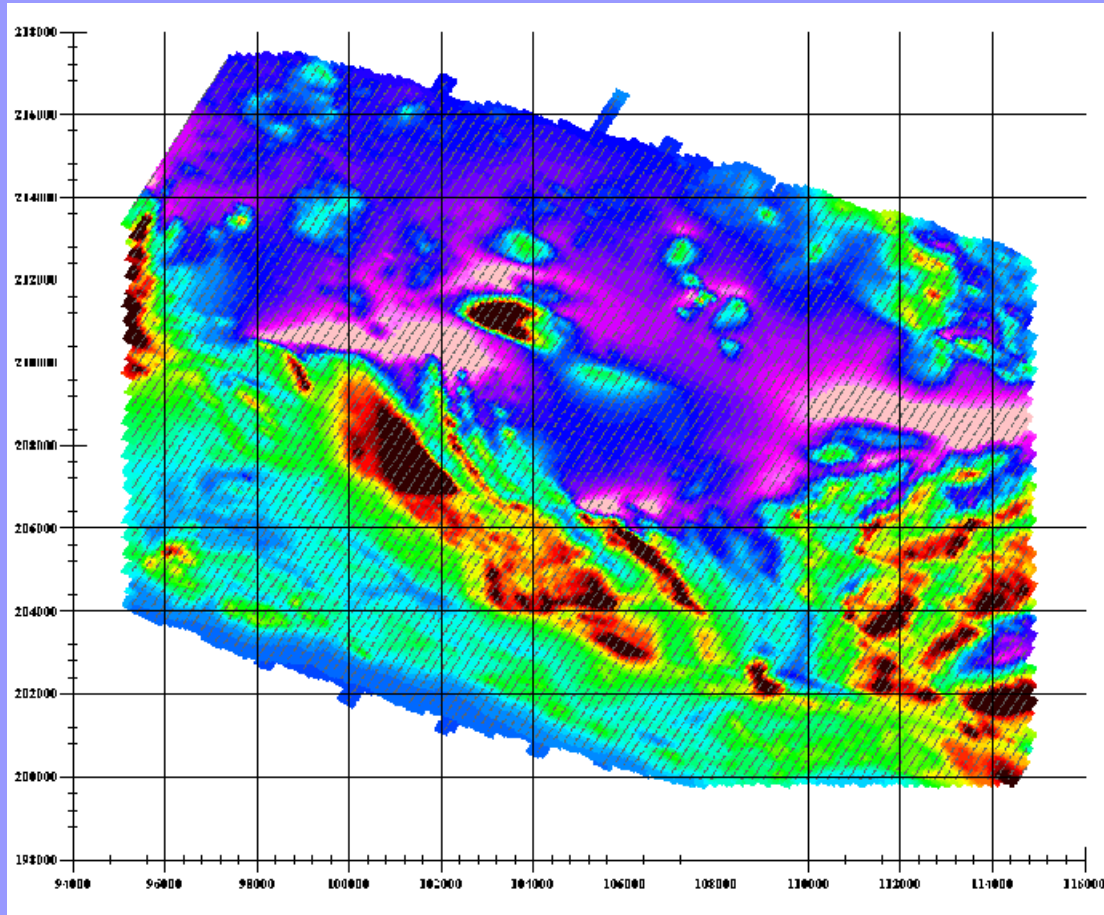## Natural Neighbour, Shepard, Delauney - Local
Minimum Curvature - global
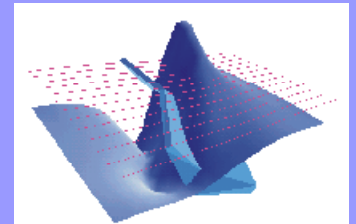

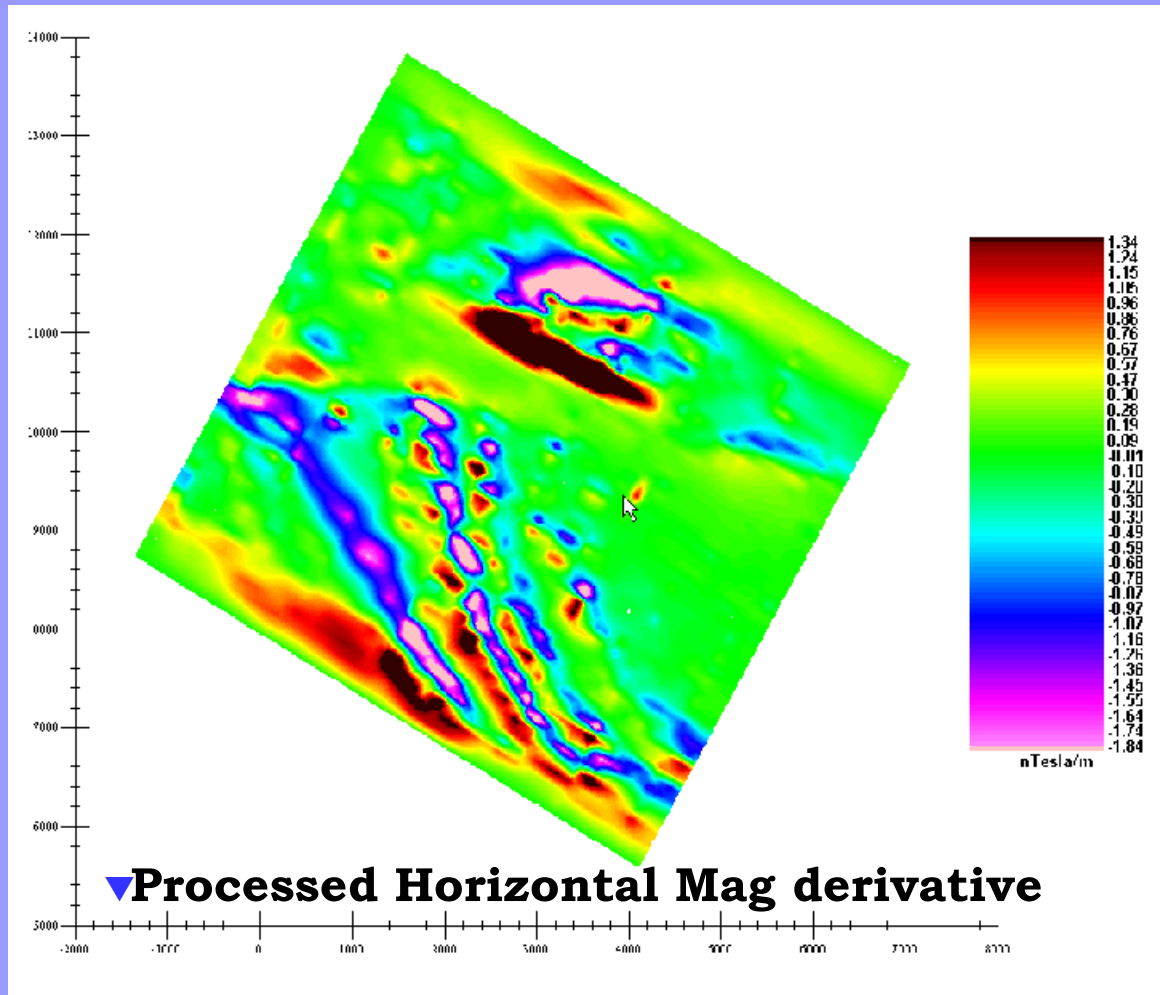**Rectangular grid cells**
Multi-component grids

Equal Weight

Equal Range

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Sophisticated software
for the practicing Geoscientist

Data Interpolation and Contouring 2

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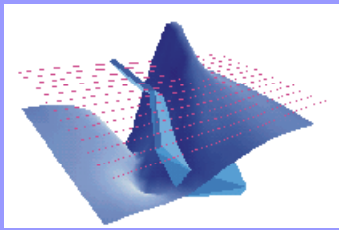- ✓ **Delauney Traingulation**
- ✓ **Minimum Curvature**
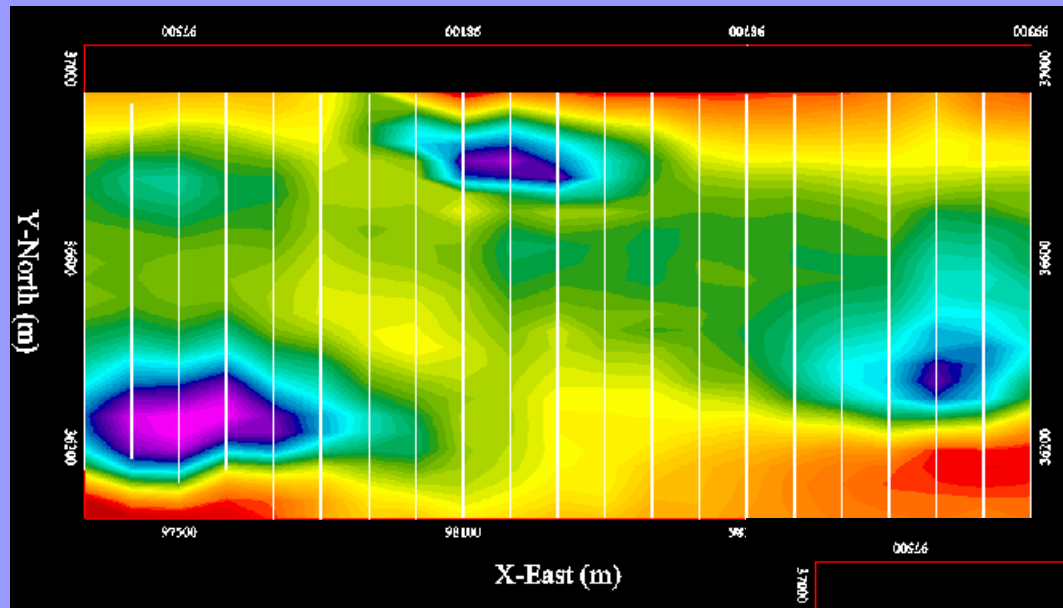- ✓ **Splines**

Data Interpolation and Contouring 3

Grid View

nTesla/m

▼**Processed Horizontal Mag derivative**

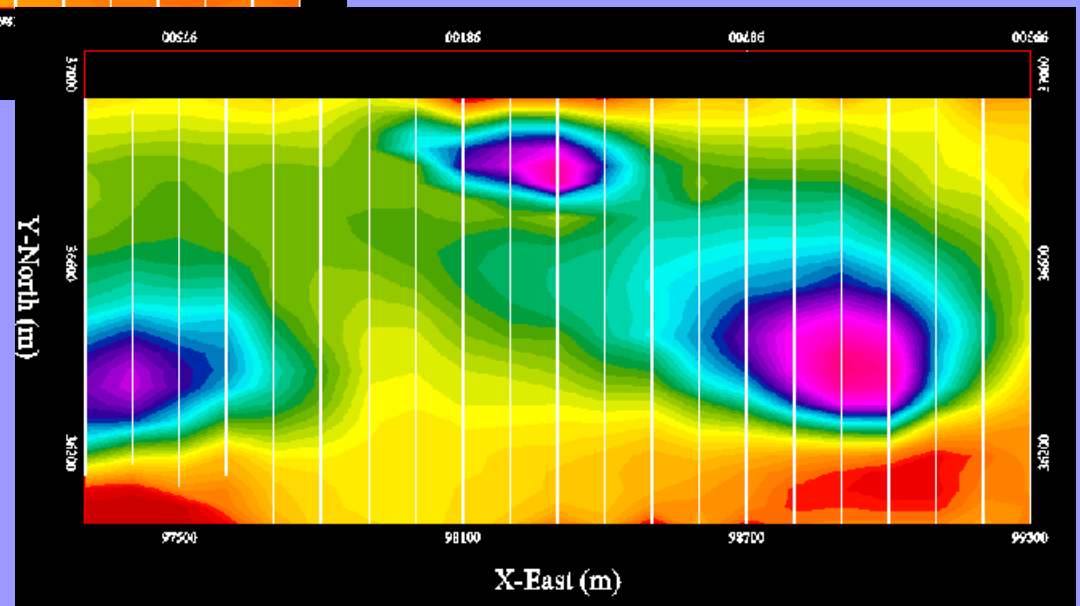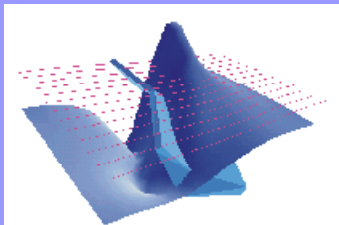**Multiple datum stored in a grid for quick viewing**
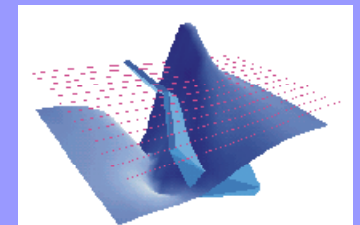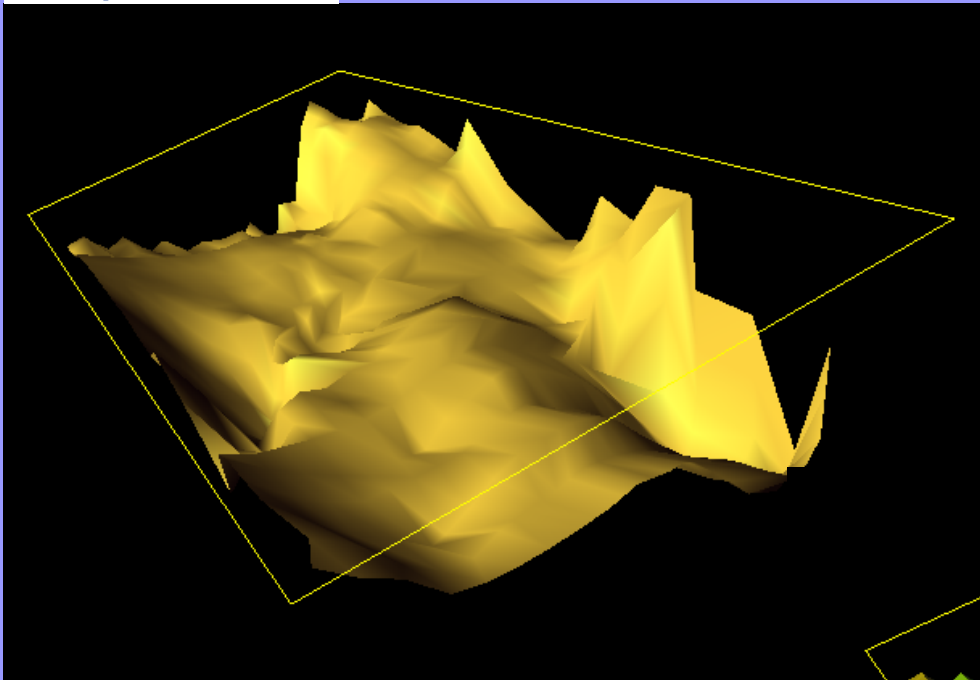
Track anomaly time evolutions

**Mid-Time
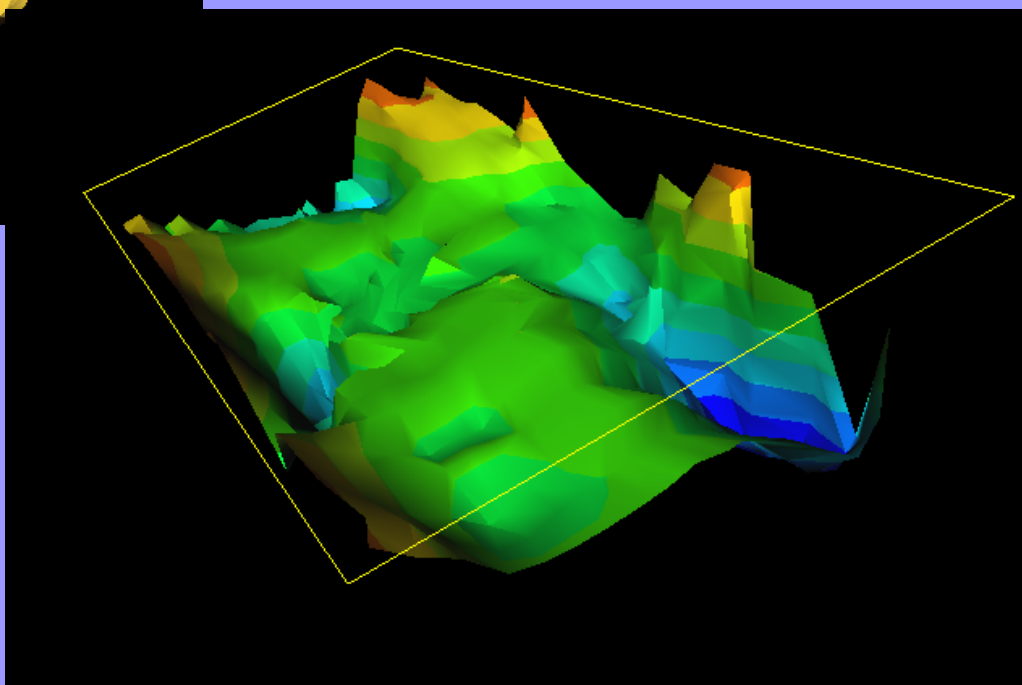TEM data**

**Late-Time
TEM data**

Surface representation of data allows for a spatial display of anomalies
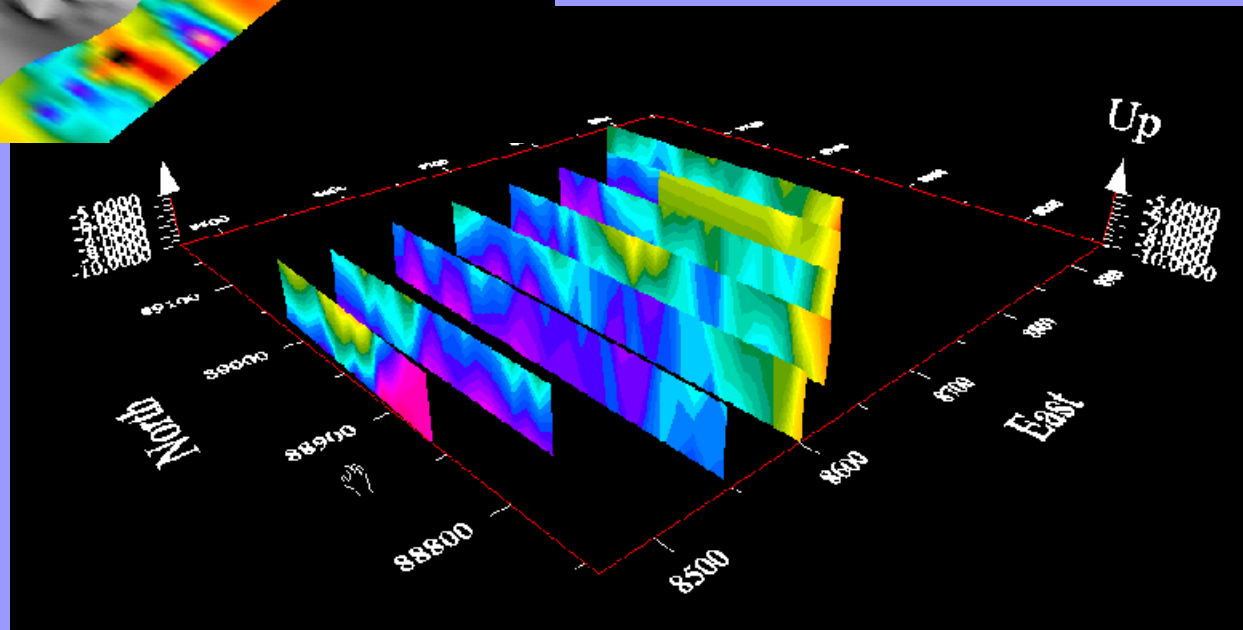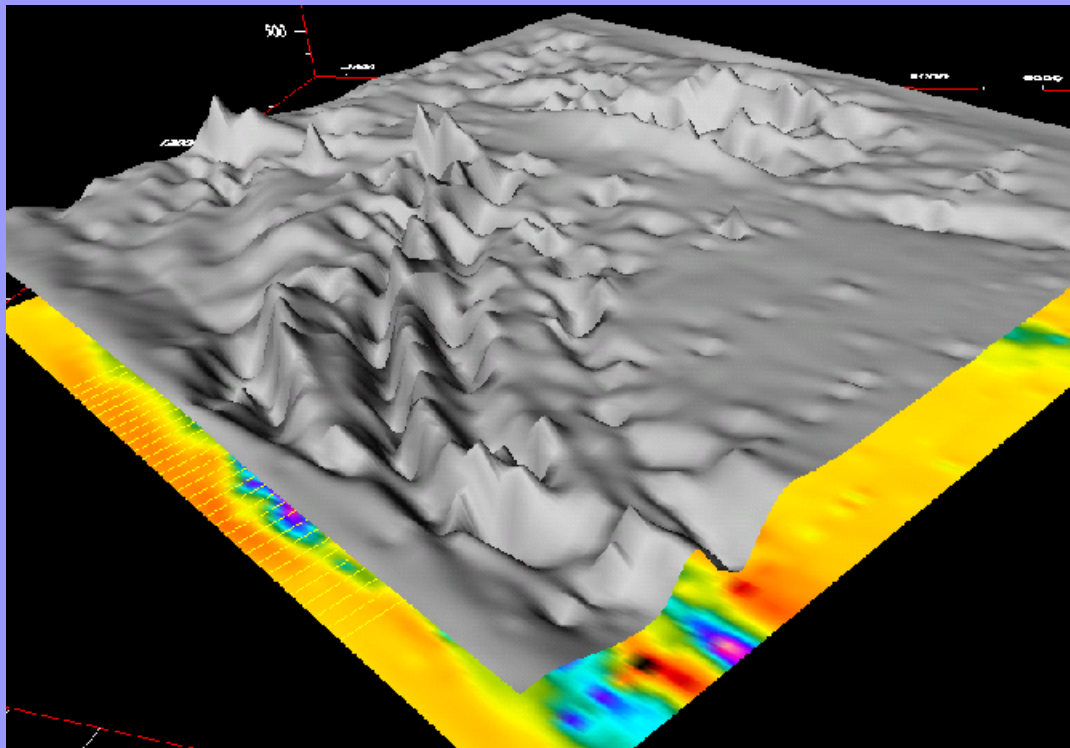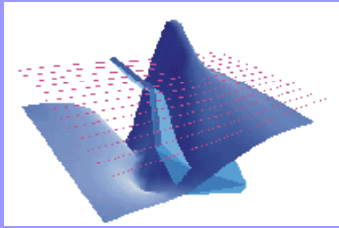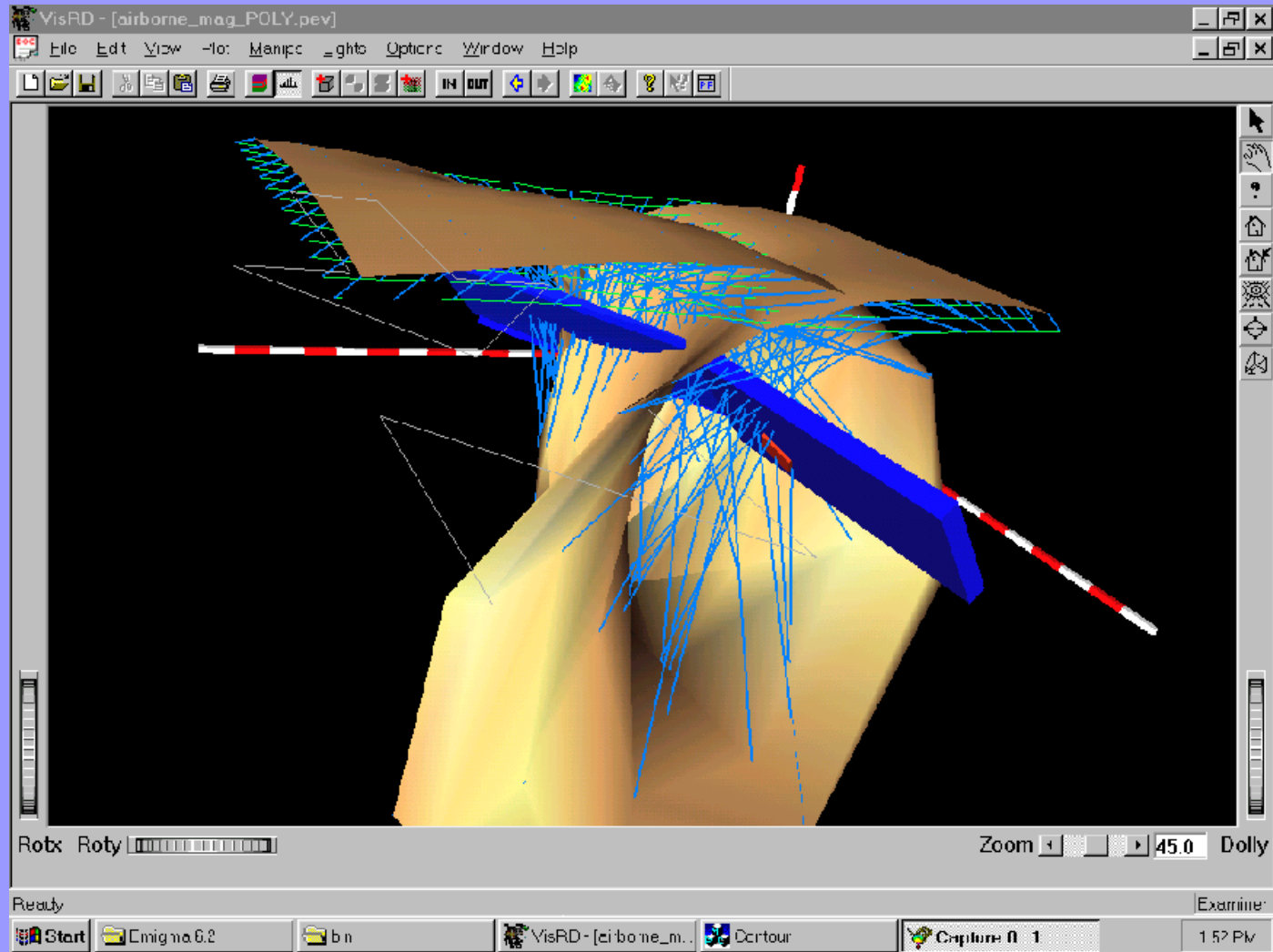
Data Surface

Contoured Data Surface
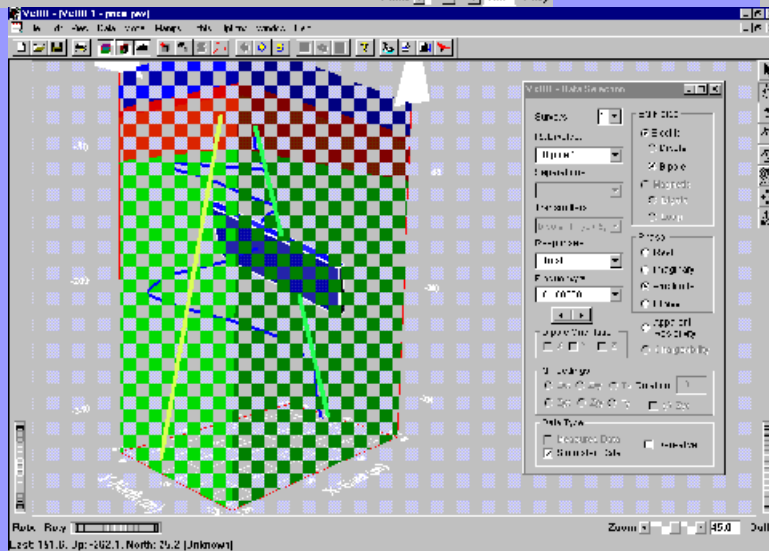
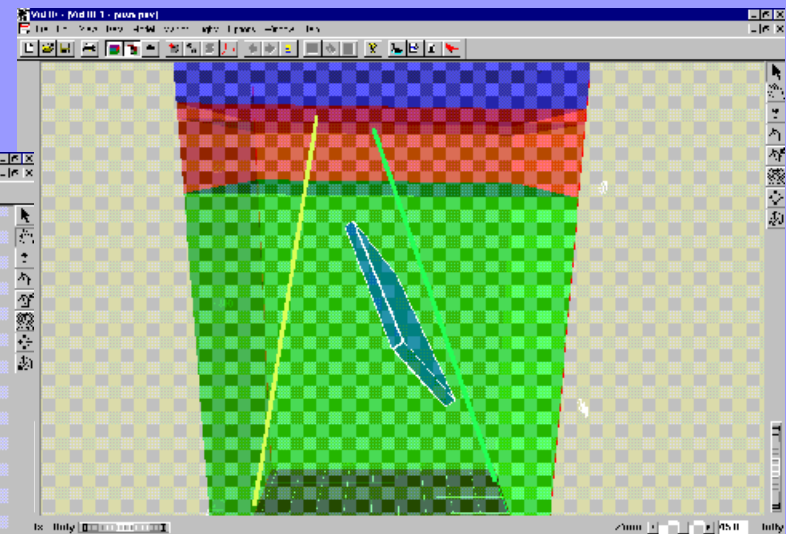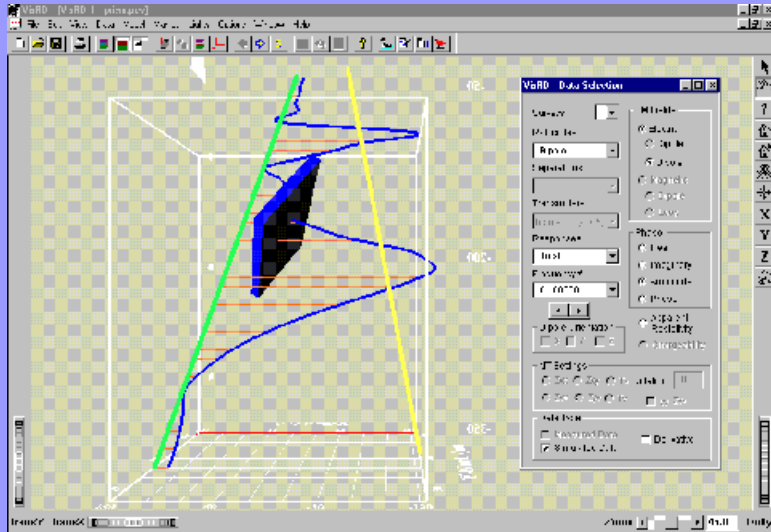# Data Interpolation and Contouring 4

A Range of 3D Data Representations

Model Building and Simulation - 1

View survey, Build models and analyse data in 3D
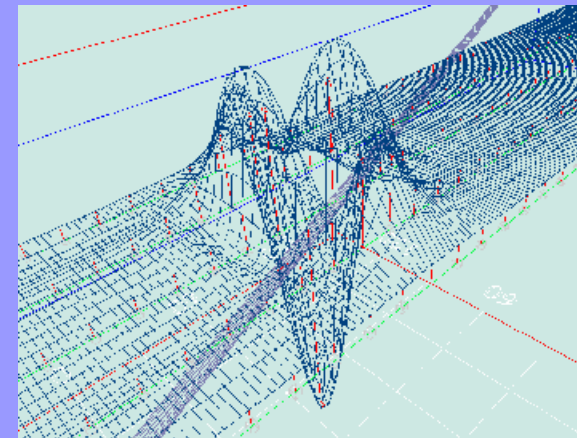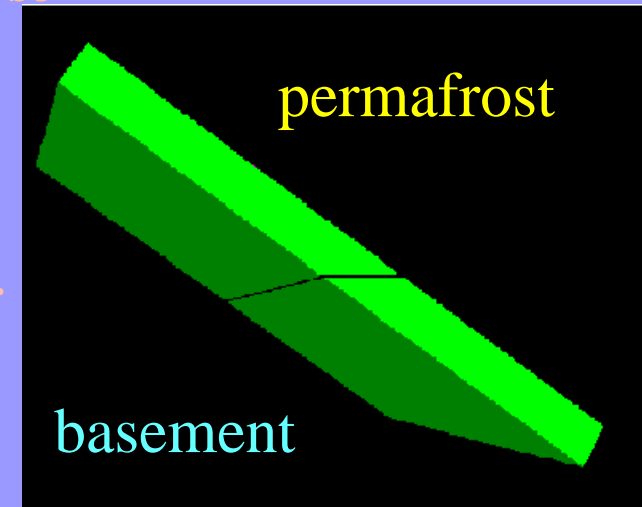
e.g. **Crosshole resistivity survey and model**
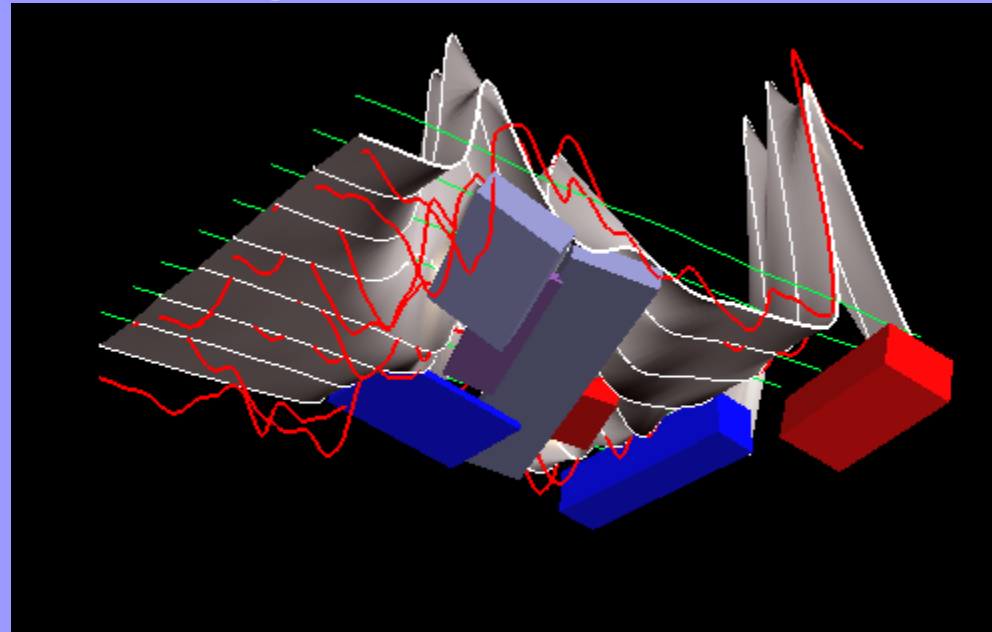
Model Building and Simulation - 2

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

permafrost

basement

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Sophisticated software
for the practicing Geoscientist

Sophisticated software
for the practicing Geoscientist

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**

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**

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for the practicing Geoscientist

_
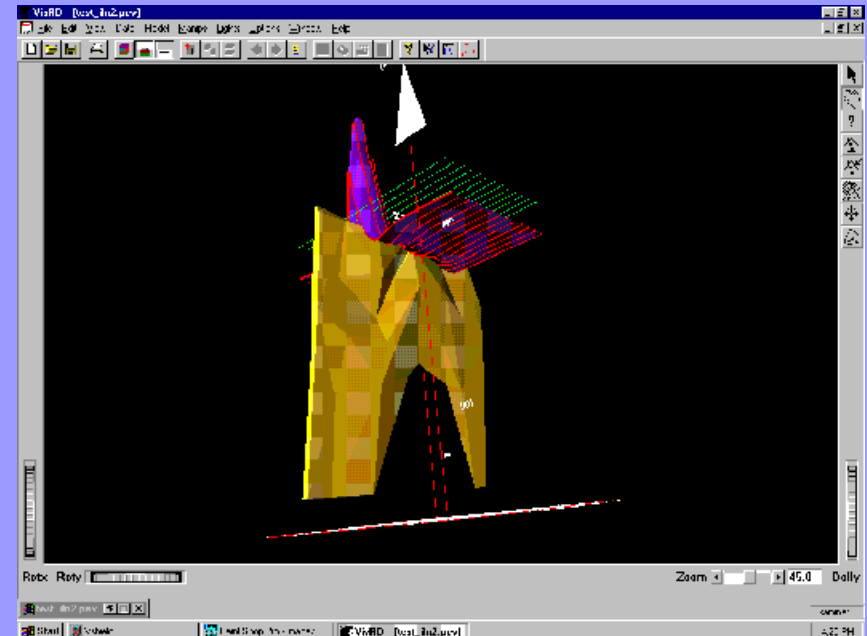
Model Building and Simulation - 5

Others

Gravity – 3D (Now available)

analytic and numerical integration – (total and vector field)

borehole modelling

gravity gradients (full tensors)

MT, CSAMT (3D)
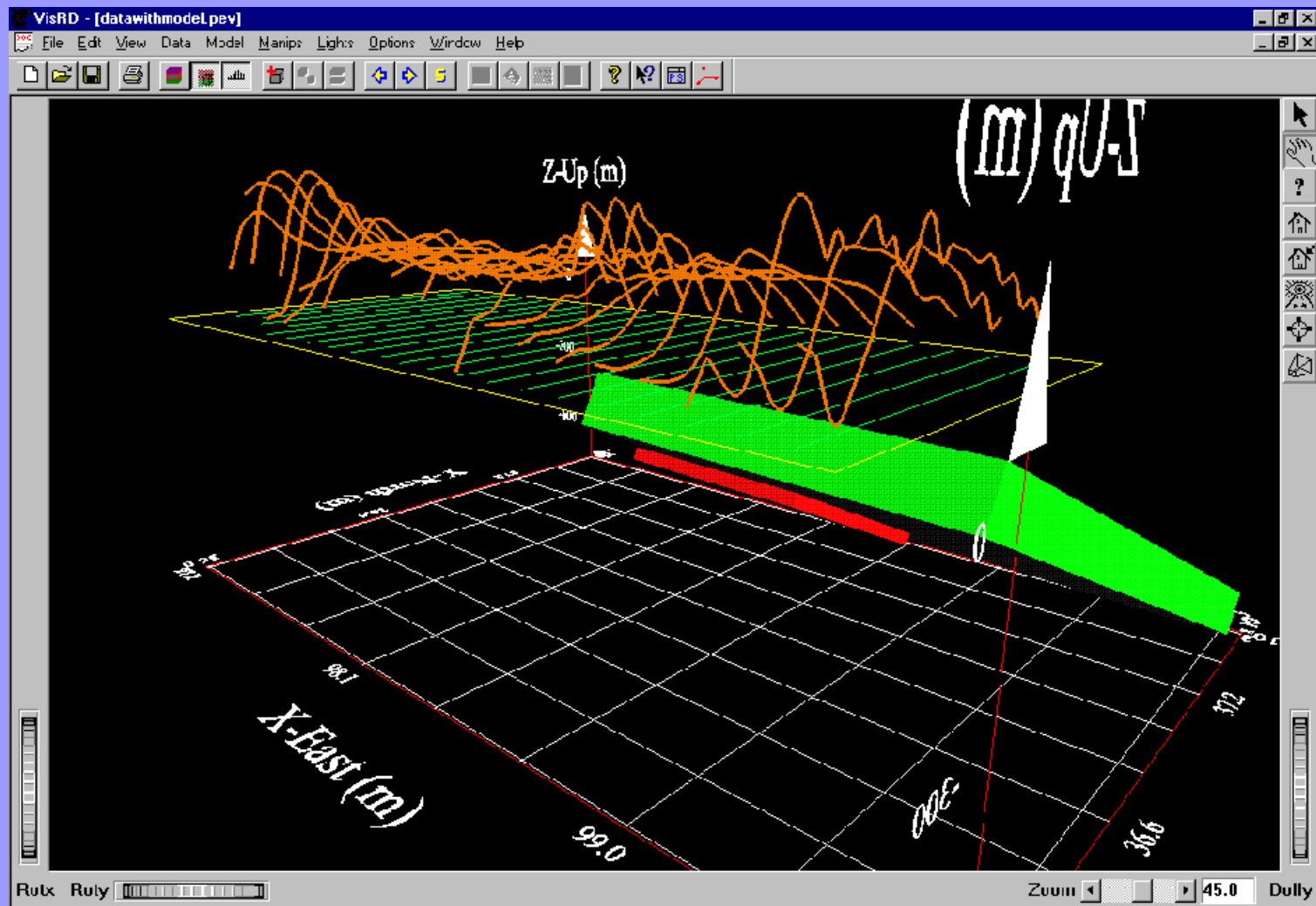
impedances or fields

Strong and Weak Interactions

Crosshole

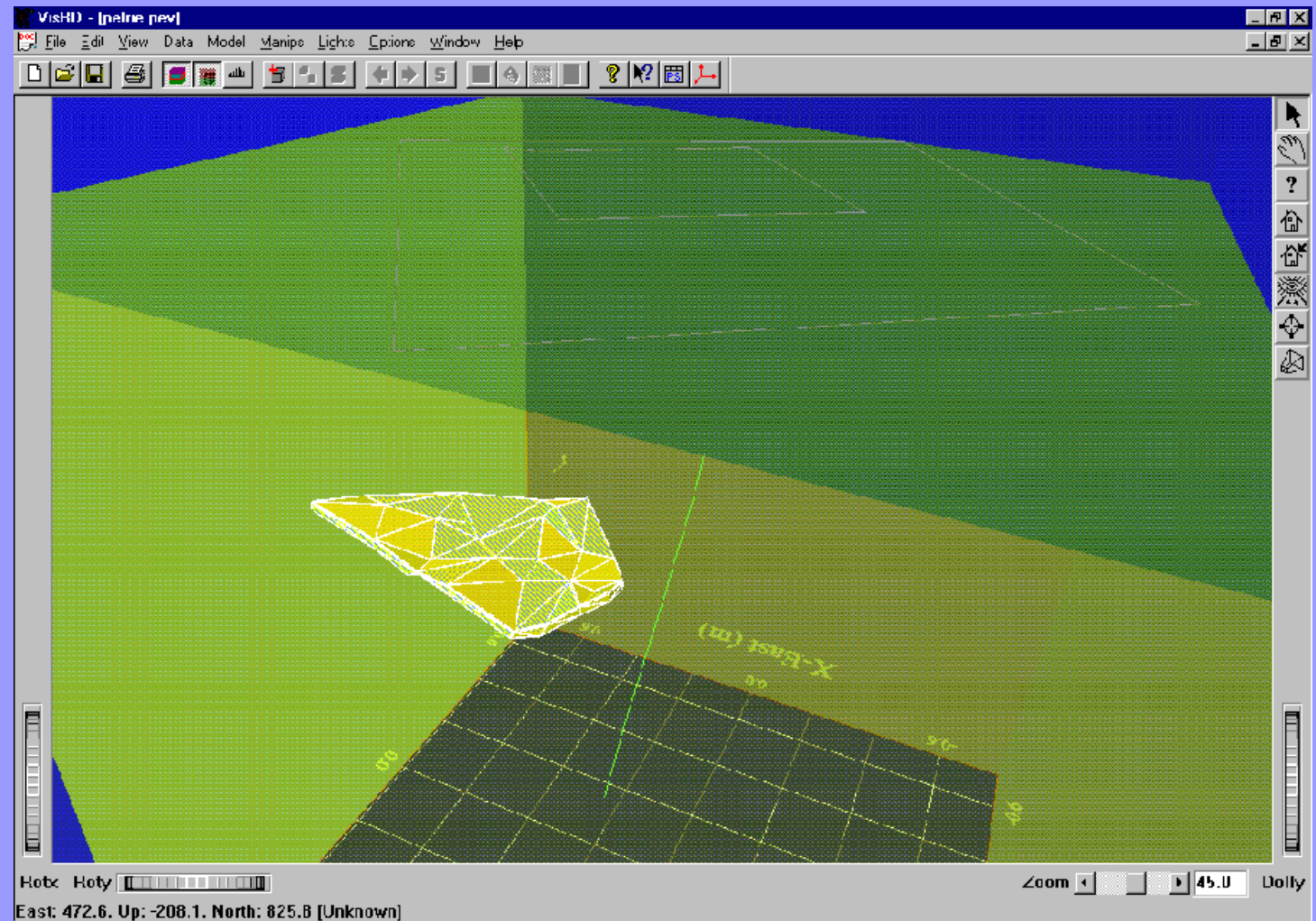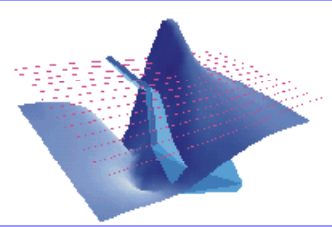electric (3 antennae types) or magnetic antennae

Experimental Systems

Sophisticated software
for the practicing Geoscientist

Data and Structure Representation in EMIGMA's 3D Visualizer

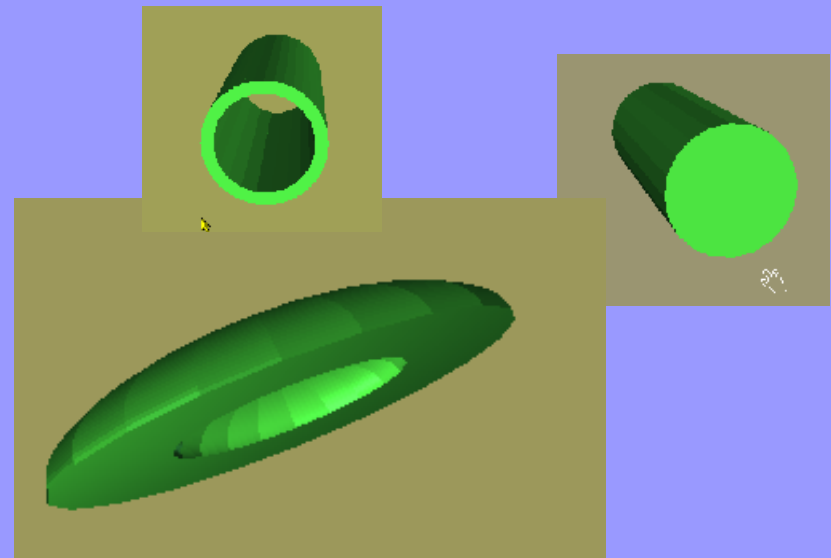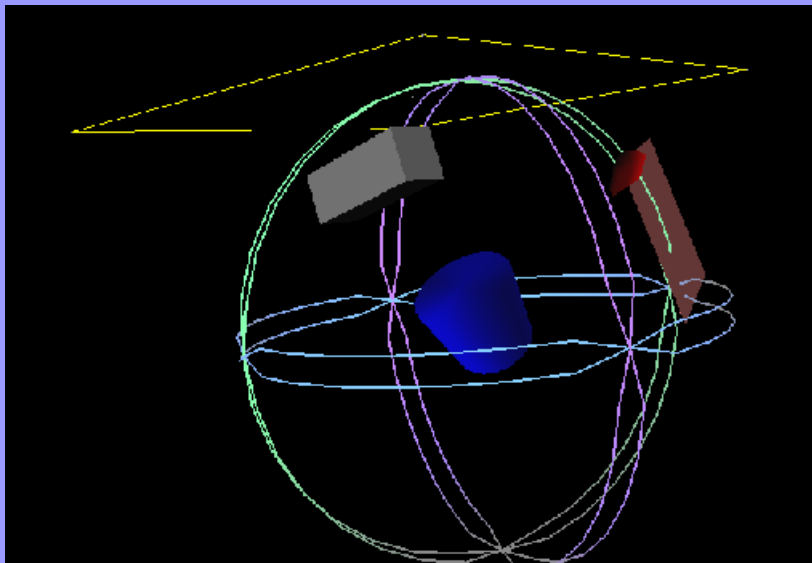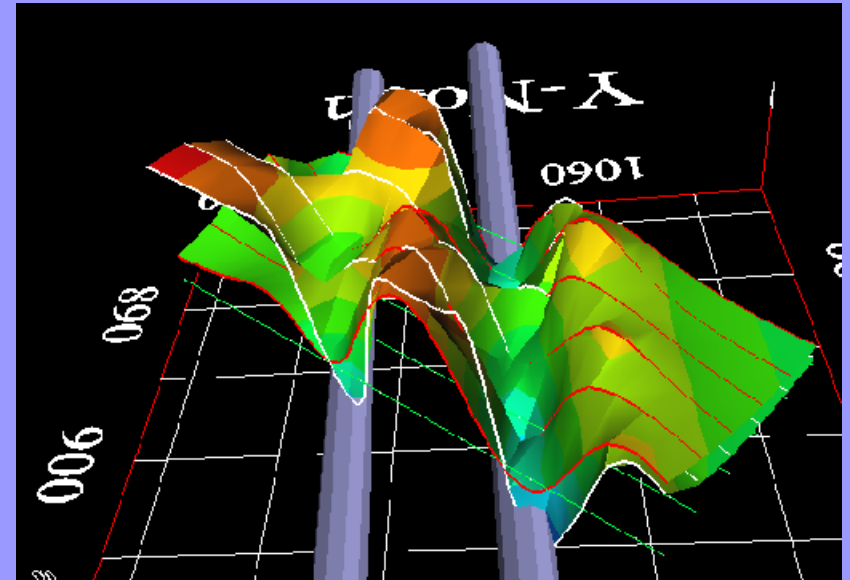**A fully integrated 3D visualization tool**
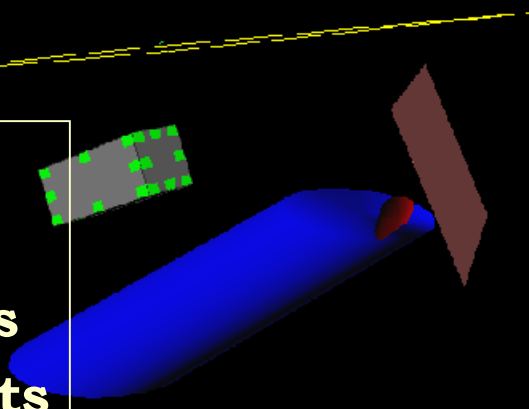
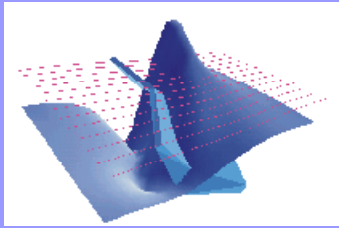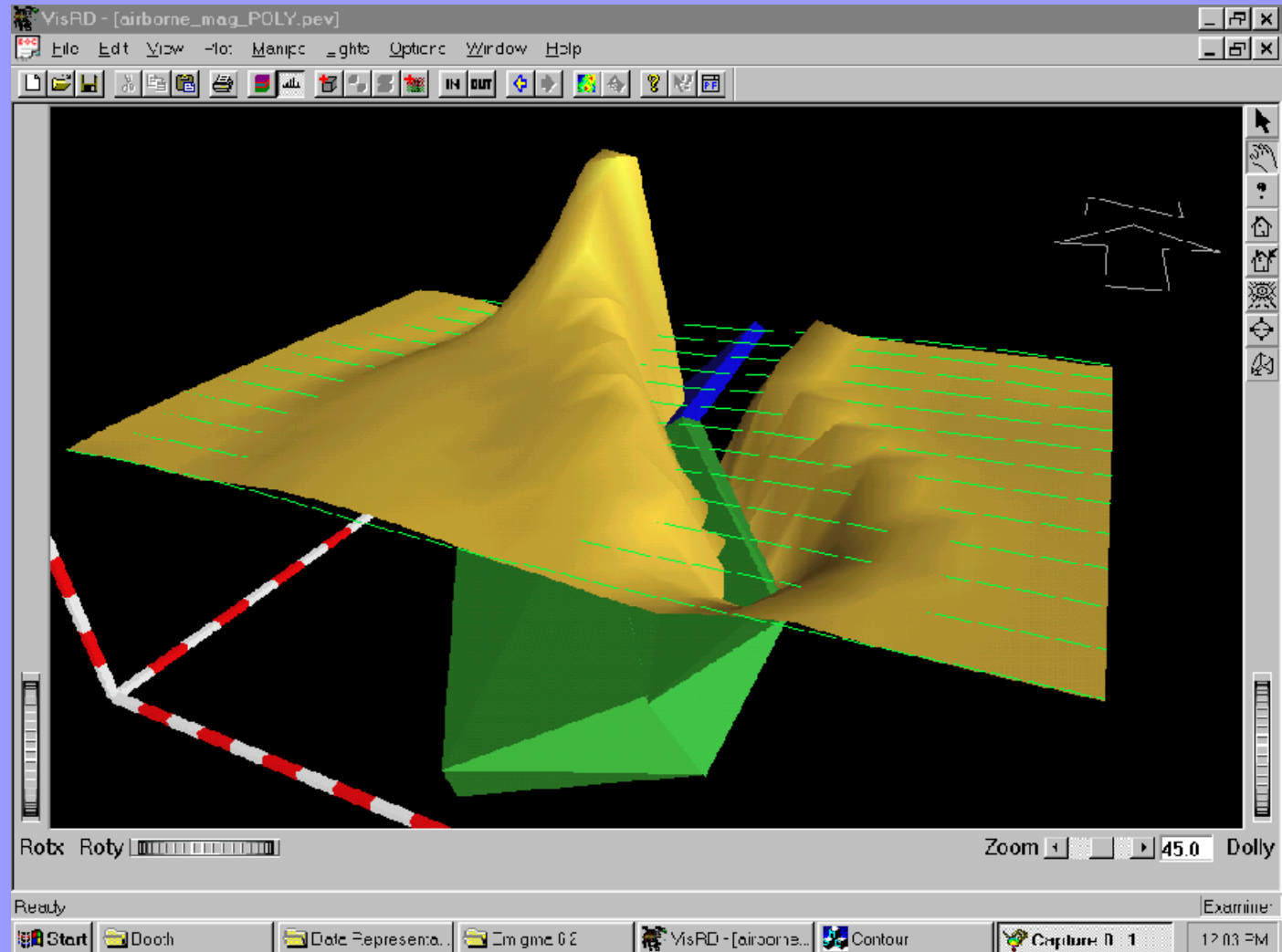**Complex 3D modelling capabilities including imports of geological models from CAD applications**
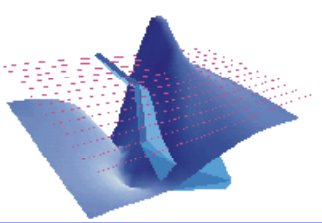
3 primitives
- **Prisms**
- **Polyhedras**
- **Thin-Sheets**
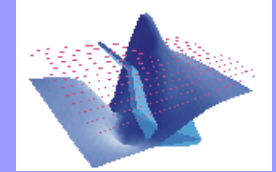
Complex Structure and Data Visualization
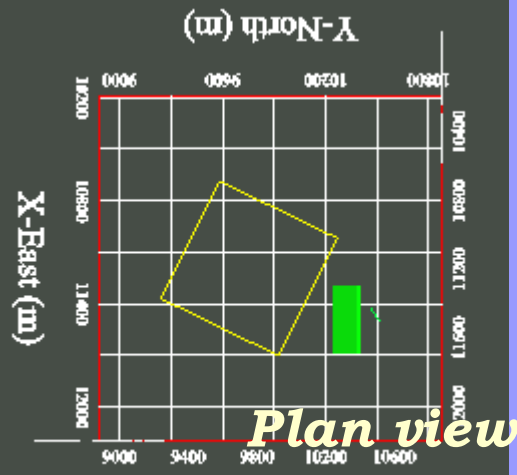

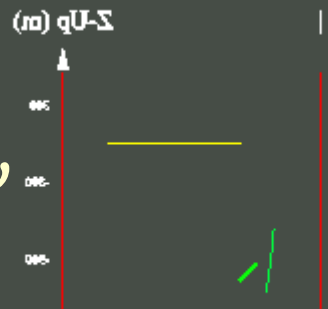## e.g Airborne Magnetic Field Modelling

Simulation Calibrations

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

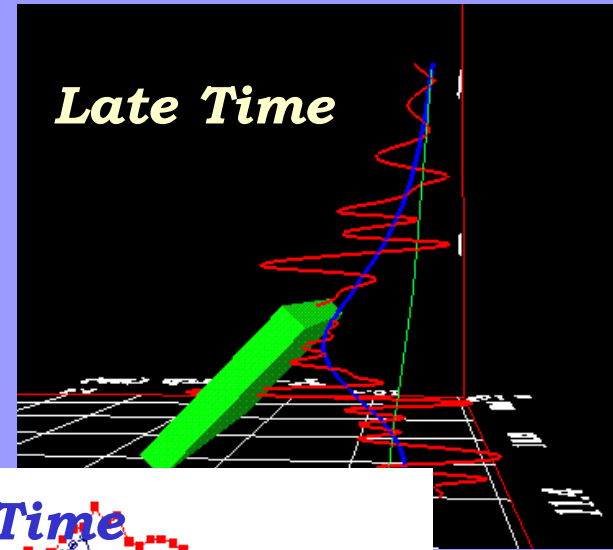**e.g TEM borehole response**

Plan view

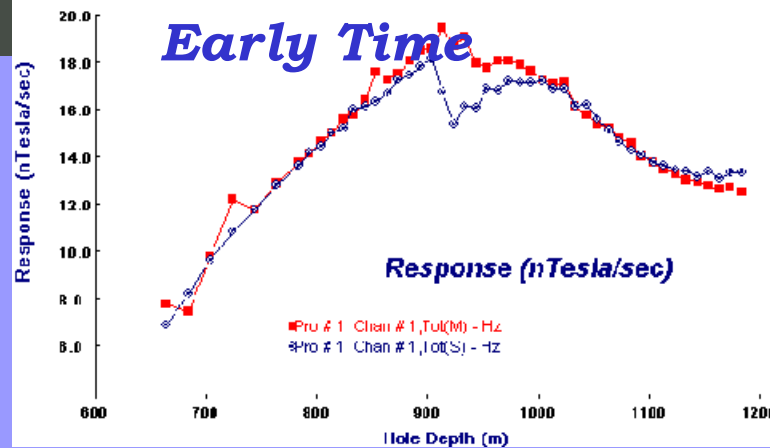**North view**

East view

Late Time

Early Time

Late Time

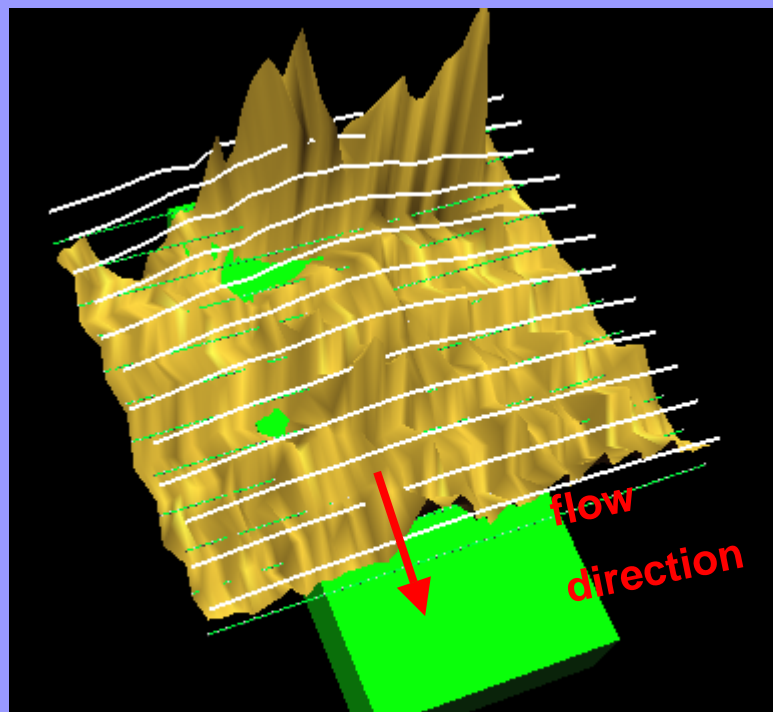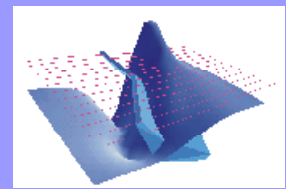**Blue line - simulated**

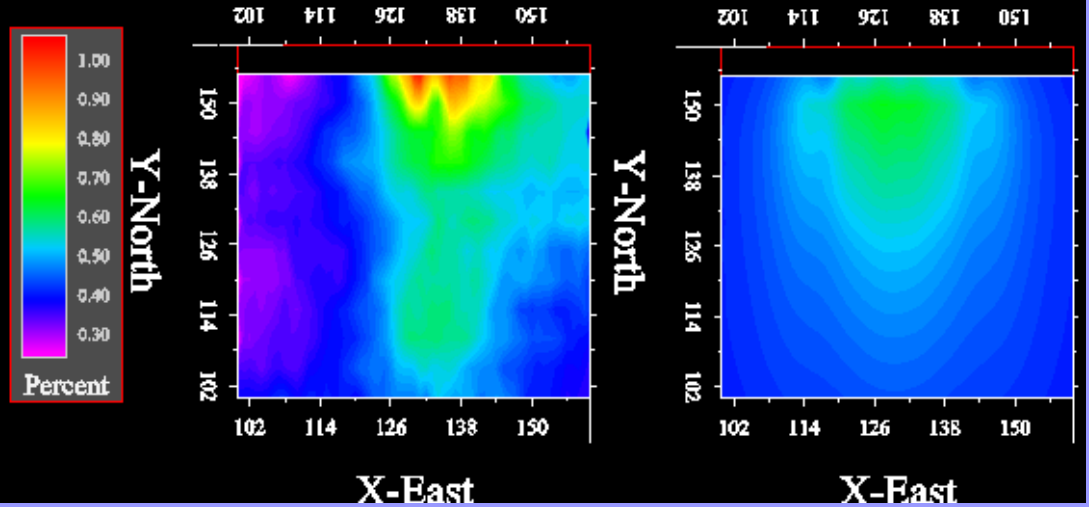**Red line -**

field data
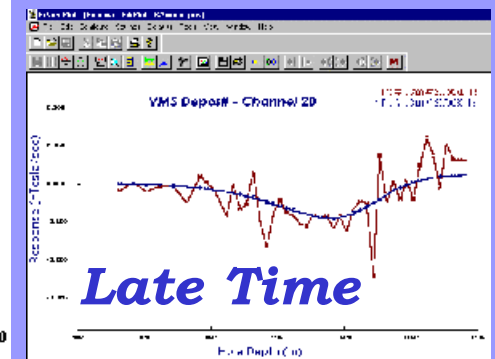
Model and Data Comparison

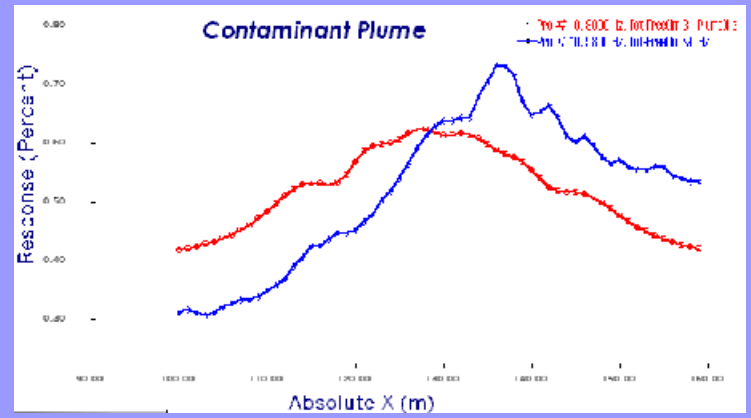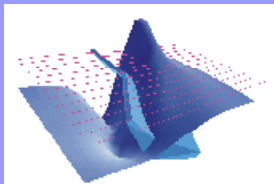**Contaminate Plume**

EM31 data

- 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

......THE POWER OF EMIGMA

MODELLING

STATIC MAGNETIC
FIELD GATHERING

ie: magnetics models

LN4MAG:
EMIGMA V6

MLN:
EMIGMA V6

ie: freespace models

EMSPHERE V4

ie: IP, resistivity models: V4

INDUCTION

CURRENT
CHANNELLING

ie: Surface and Borehole TEM
VHPLATE: EMIGMA V4
ILN: EMIGMA V5

ie: CSAMT, MT
LN: EMIGMA V3

EM-3D, ETC

PETROS EIKON, 1999
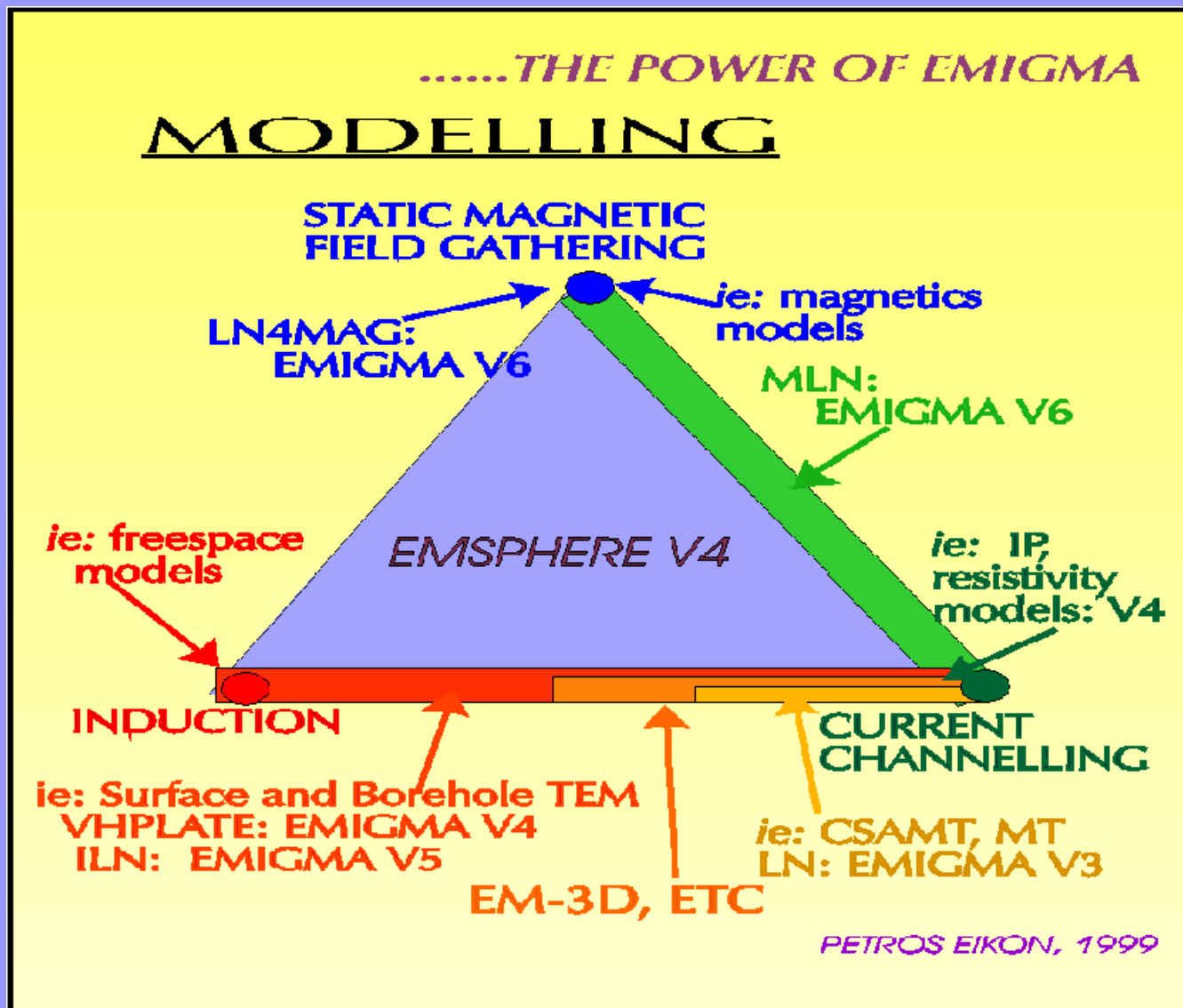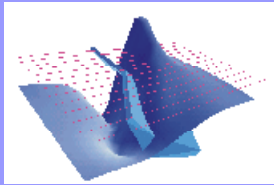
Geophysical Responses

◣ **EMIGMA Algorithms**

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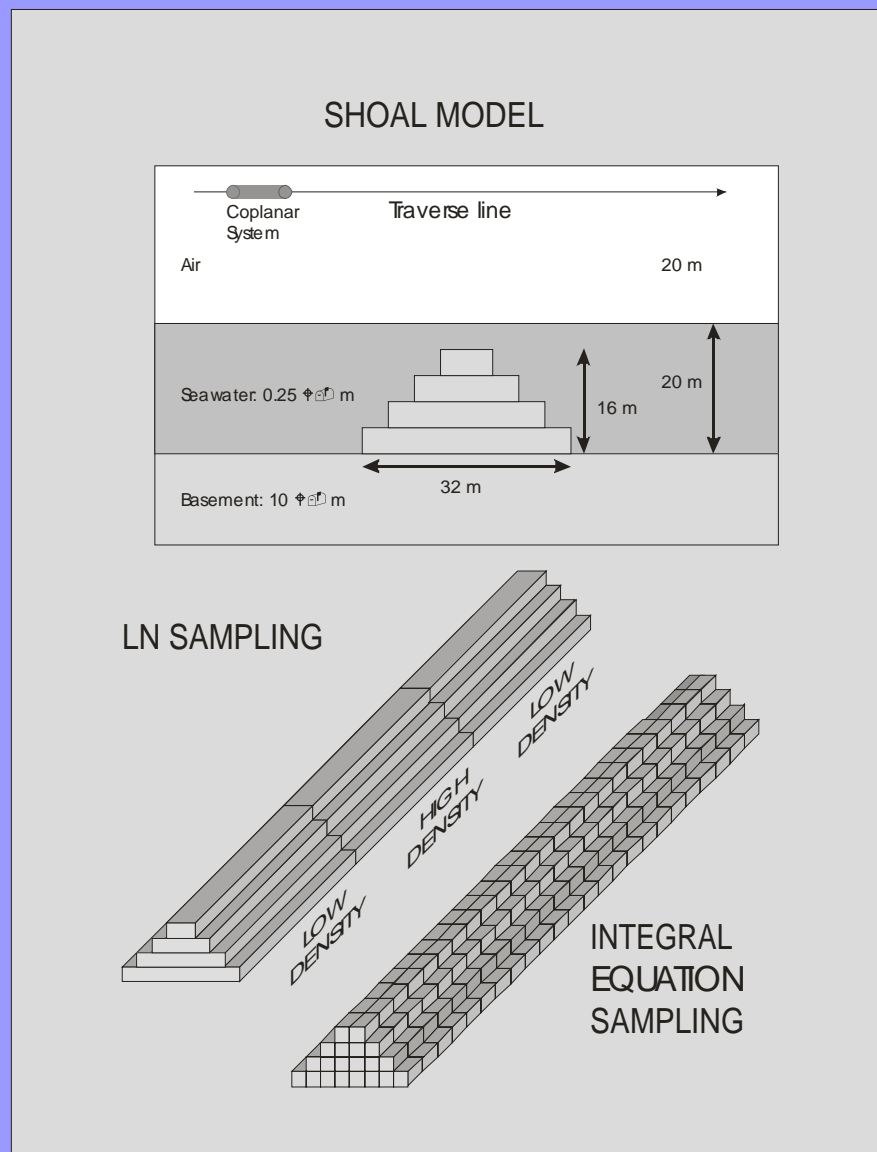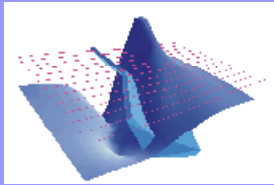- **Born techniques**
- **3D Resistivity (fast,flexible,accurate)**

MODES OF RESPONSE

CHANNELLING
(Current Gathering)

Current

MAGNETIC FIELD
GATHERING

Magnetic Field

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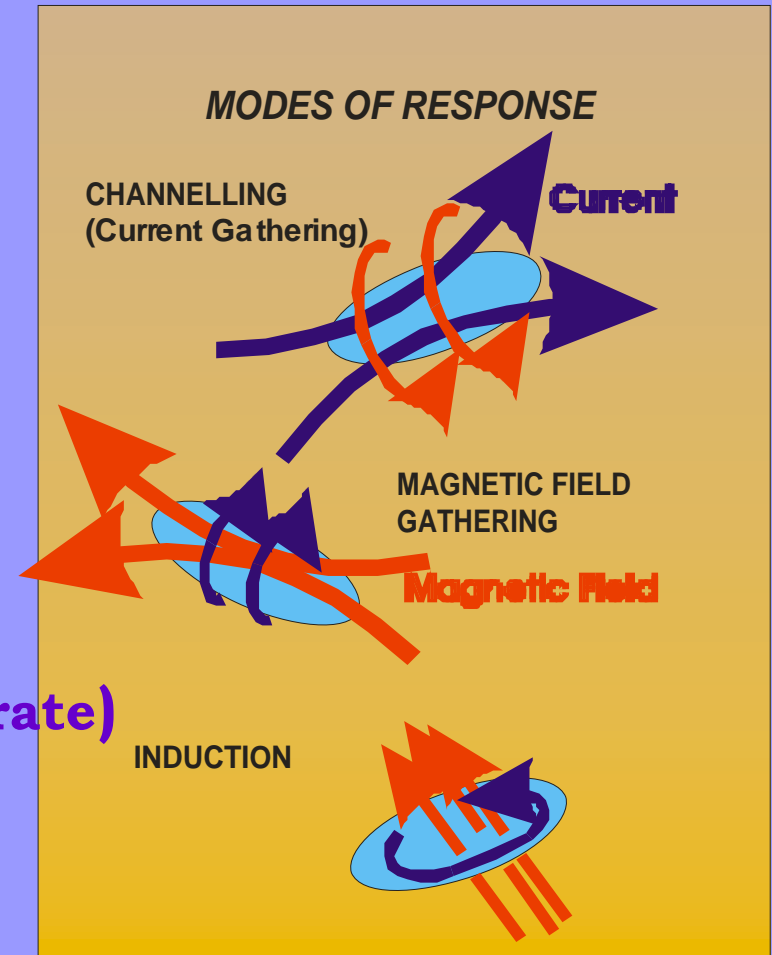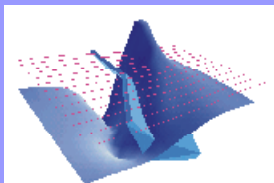
EMIGMA Algorithms
- **LN**
- **EiKPlate**
- **ILN**
- **MLN**

Rapid Convergence
Flexible and
Easy-to-Use Grids

SHOAL MODEL

Coplanar System
Traverse line

Air   20 m

Seawater: 0.25 ℧ m   20 m
                                  16 m

Basement: 10 ℧ m   32 m

LN SAMPLING

LOW DENSITY
HIGH DENSITY
LOW DENSITY

INTEGRAL EQUATION SAMPLING

Complex Models
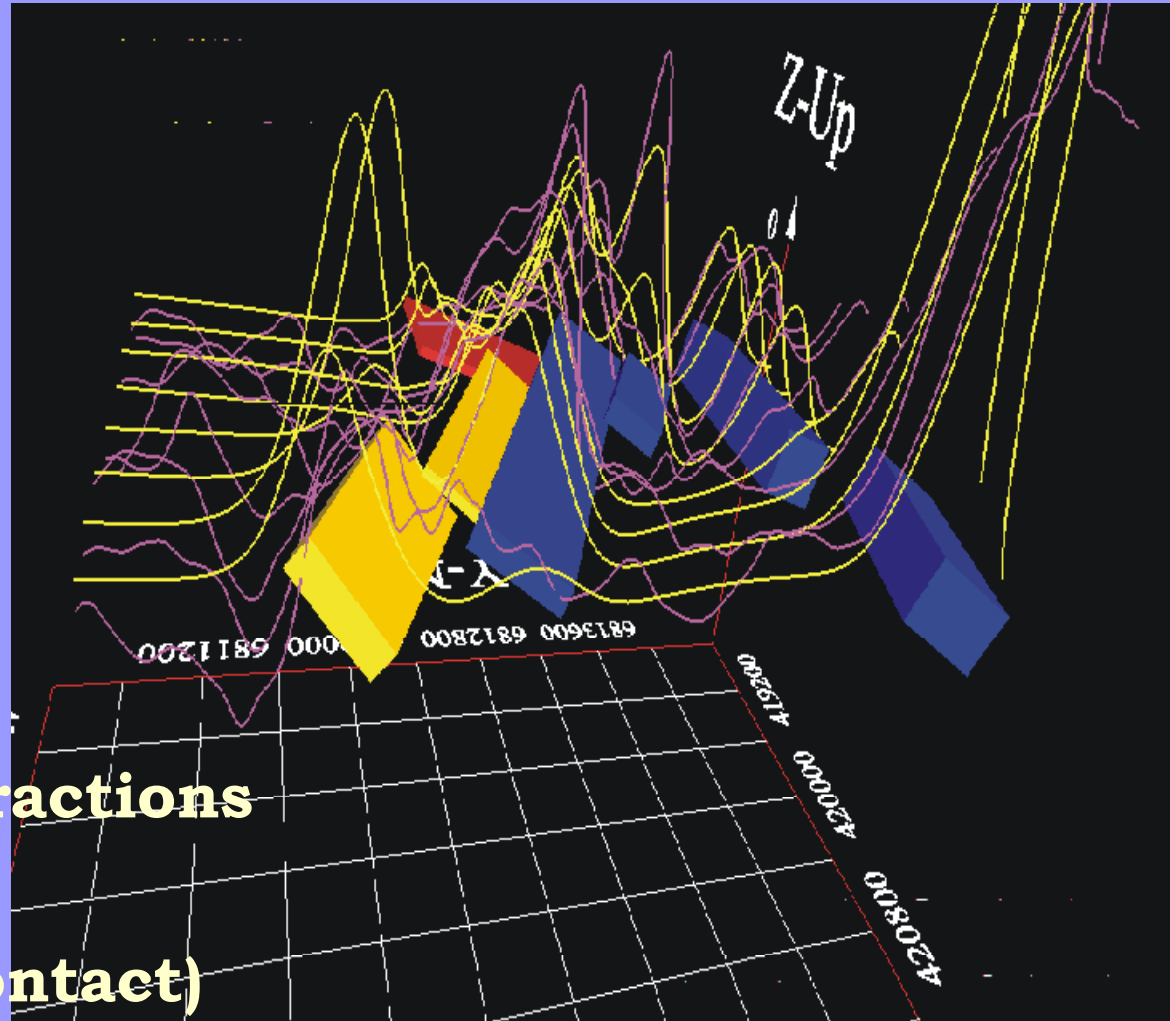
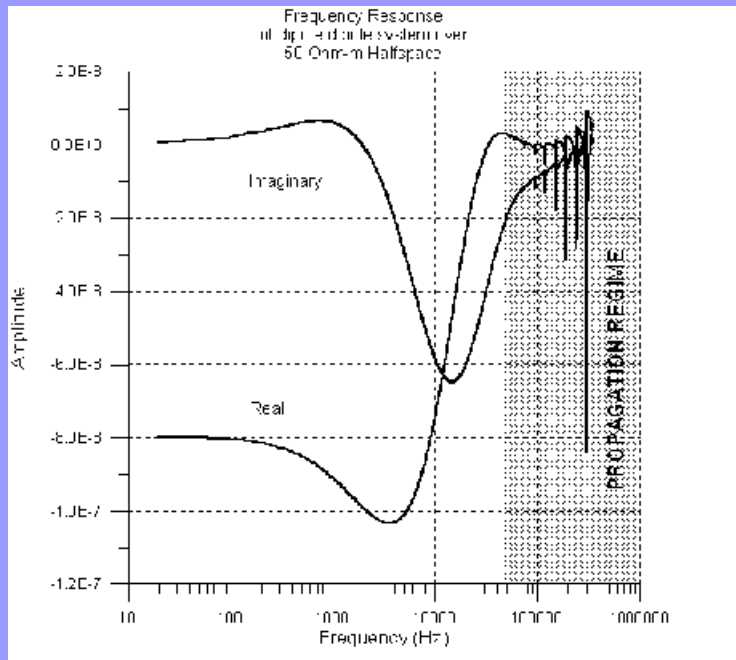

Full Range of

Target Interactions

- **Superposition**
- **Near-Field (in contact)**
- **Interaction at a distance**
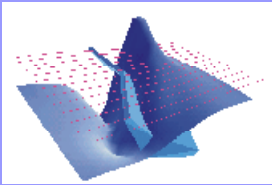
3D Modelling Capabilities 4

Frequency to Time-Domain Transform

▼ **Why**

▼ **How**

▼ **Waveforms**

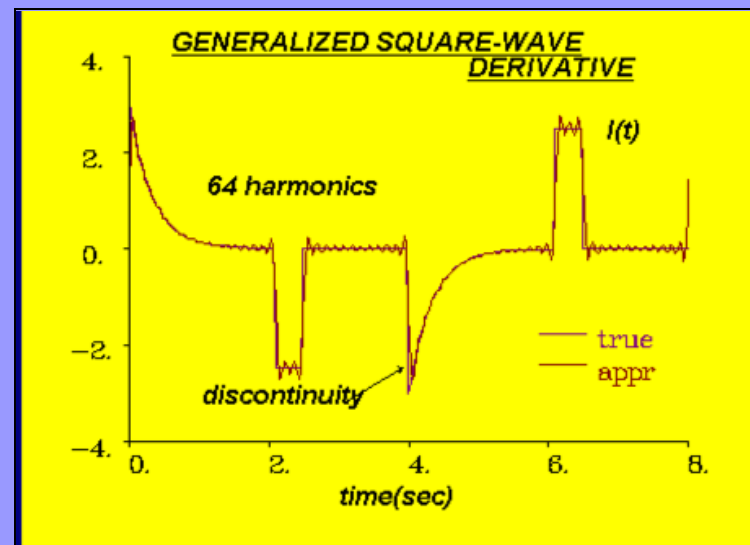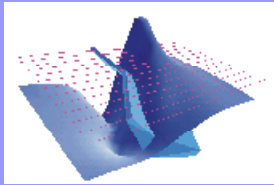▼ **Bandwidth**

Typical Magnetic Response

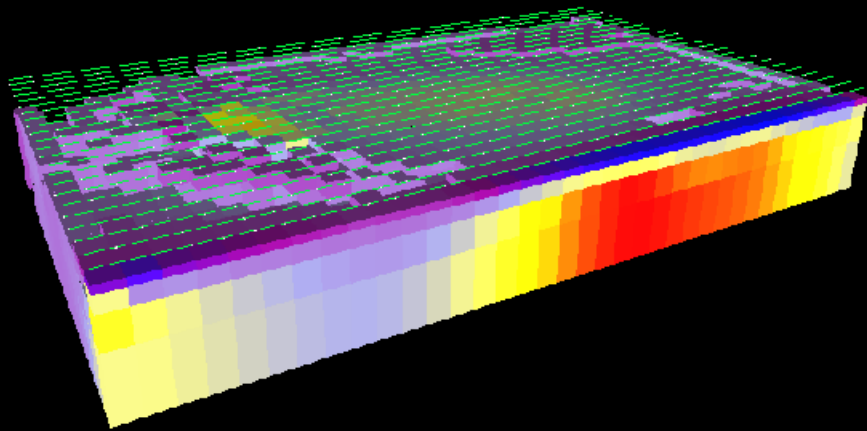**Figure 15:** Fourier representation of derivative of the Generalized Square Wave using 64 harmonics.

Band limited Coil Response

Incredibly accurate transforms

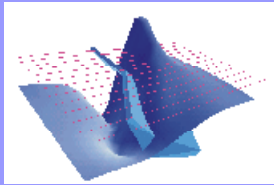# 3D Magnetic field Inversion for Susceptibility

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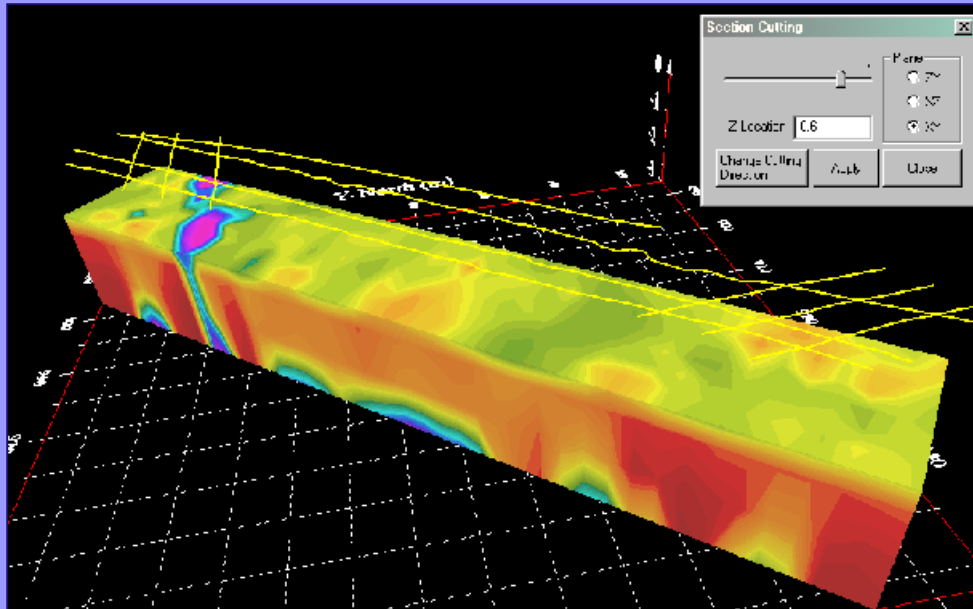**– ground , HEM, fixed wing**
joint resistivity and
susceptibility

TEM – multiple basefrequency
capabilities
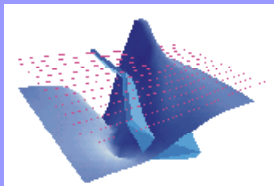*- in-loop, out-of-loop*
- ground, airborne

Resistivity: 1D Inverson

Sengpiel Sections:
HEM, Fixed-Wing

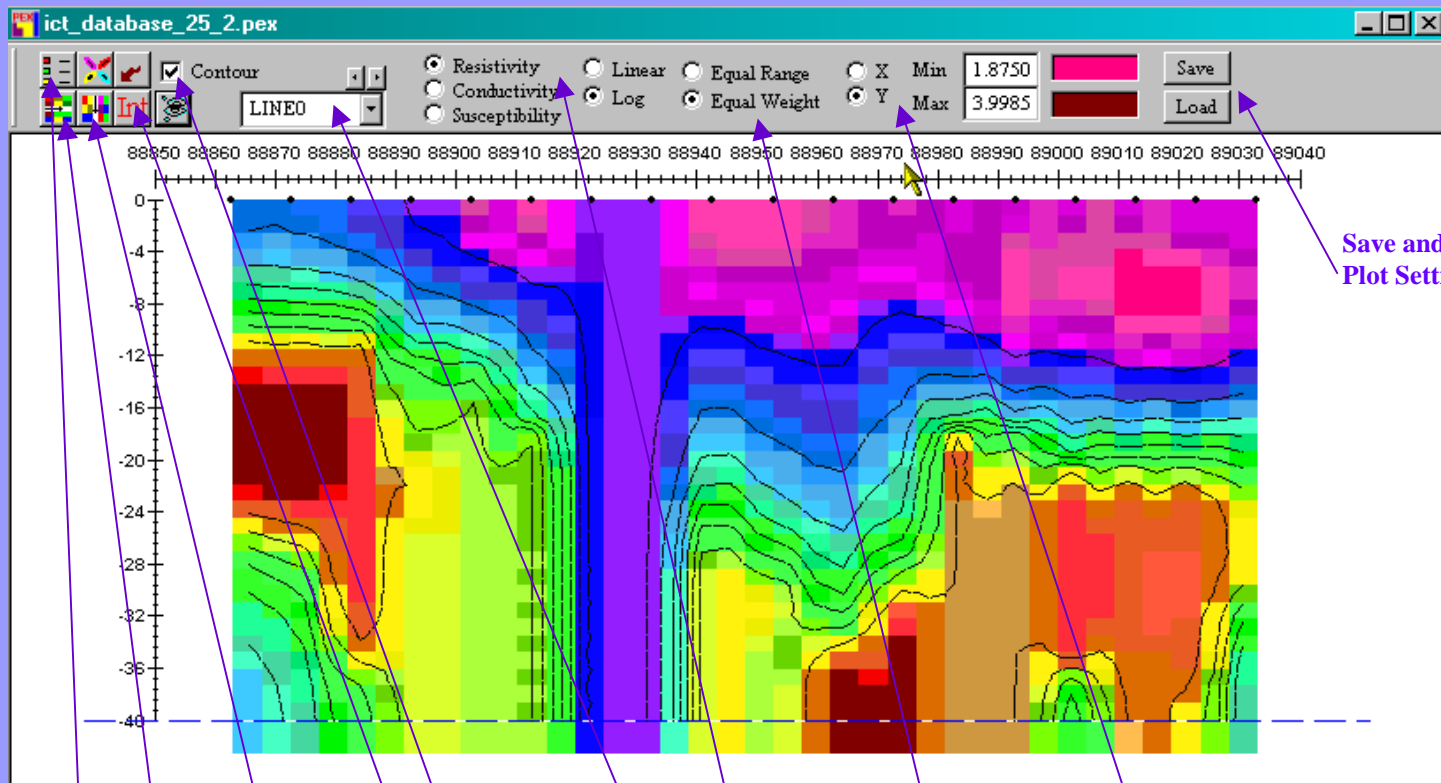*FEM, TEM Apparent Resistivity*
HEM and Ground

Inversion Capabilities 3
PEX- file Viewer

ict_database_25_2.pex

Contour   LINE0
Resistivity   Linear   Equal Range   X   Min 1.8750   Save
Conductivity   Log   Equal Weight   Y   Max 3.9985   Load
Susceptibility

Save and Retrieve
Plot Settings

Legend

2D Interpolation

Horizontal Axis selection

Interpolate
Vertically

Apply Contour

ModelUnits

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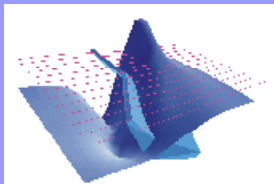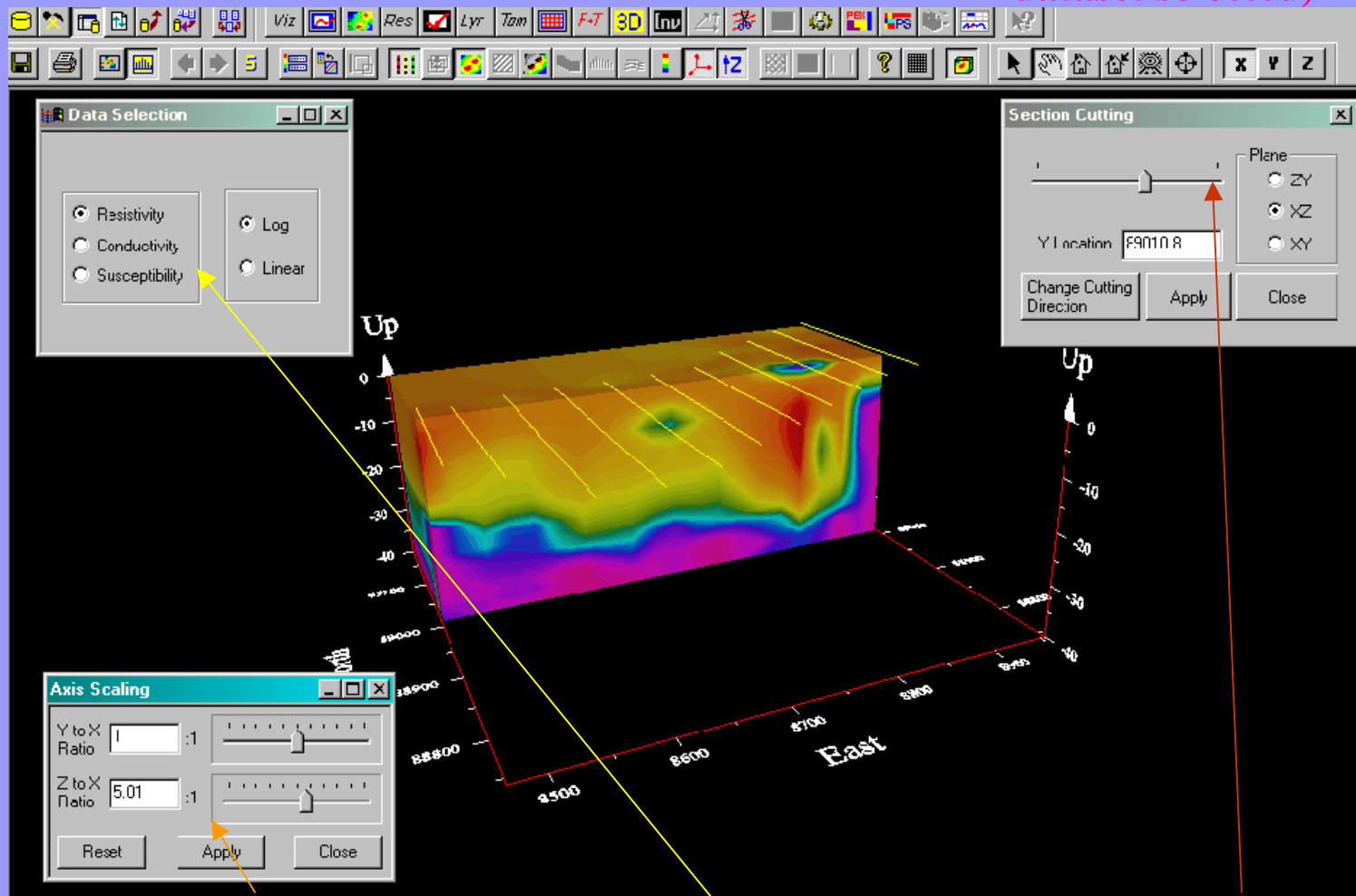
Colour Distribution
Equal Range – intervals equal
Equal Weight – distribution equal

Interpolate Horizotally

Inversion Capabilities 4

**3D Volume Contour
(with Inversion model
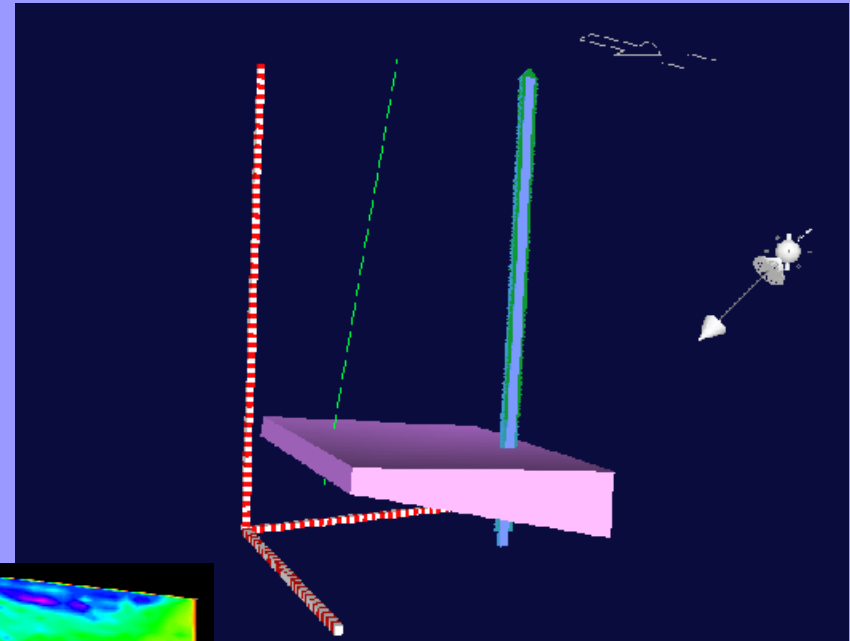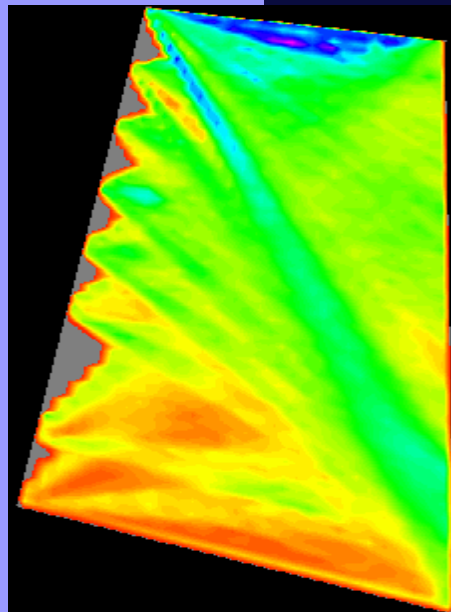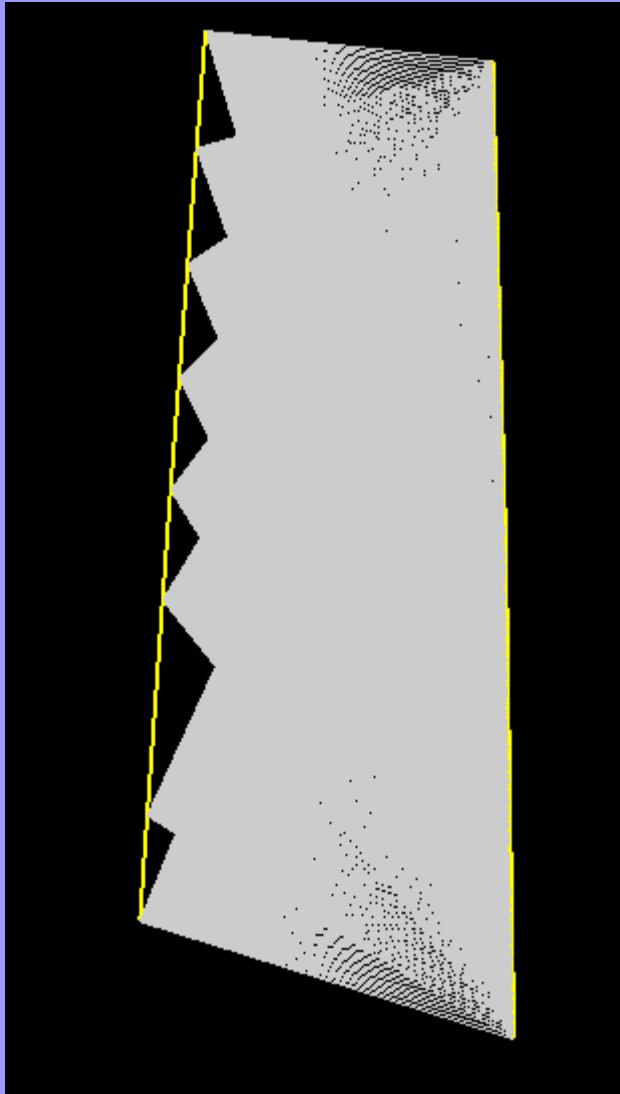dataset selected)**

Axis Scaling   **Model Units**   **Section Cutting**

Crosshole Applications

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**

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For more information:

sales@PetRosEiKon.com

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