

EMIGMA V8.x – Manual

Premium and Professional editions

The screenshot displays the EMIGMA V8.x software interface. The main window is titled "EMIGMA 8.1 - Plotter - Airb_mag_Inversion - Magnetic Grid 2_backup_edit - Measured _105_134_1". The interface includes a menu bar (File, Configure, Settings, Defaults, Draw, Tools, View, Window, Help) and a toolbar with various icons. The main workspace is divided into several panels:

- Visualizer - Airb_mag_Inversion - Magnetic Grid 2_backup_edit - Optimal_HvBorr**: Shows a 3D perspective view of a magnetic grid model with a color gradient from purple to yellow, overlaid on a grid. The axes are labeled X, Y, and Z.
- Plotter - Airb_mag_Inversion - Magnetic Grid 2_backup_edit - Measured _105_134_1**: Displays a line graph titled "Mag Response". The y-axis is labeled "Magnetic Intensity (nTesla)" and ranges from 1986.4 to 52010.4. The x-axis represents distance. Two data series are plotted: "Line3, Plot # 1, Tot(I M) E" (red line with diamond markers) and "Line3, Plot # 2, Tot(I S) E" (blue line with square markers).
- Project Configuration Dialog**: A window titled "Project: Airb_mag_Inversion /Data Set: Optimal_HvBorr in Database: E:\EMIGMA\Work Database\Example1" with tabs for Database, Data Processing, Data Correction, and Data Reduction. It contains the following information:
 - Projects in Database**: A list of projects including "Airb_mag_Inversion" (selected).
 - Surveys in Project**: A list of surveys including "Magnetic Grid 2_backup_edit" (selected).
 - Data Sets in Survey**: A list of data sets including "Optimal_HvBorr" (selected).
 - Survey Information**: Survey Name: "Magnetic Grid 2_backup", Survey ID: "120".
 - Data Set Information**: Data Set: "Optimal_HvBorr", Data Set ID: "839", Date Created: "3/19/2006 6:52:07".
 - Model Information**: Model Name: "Optim_HvBorr", Data File Name: "ExampleDatabase_839.dat".

At the bottom of the interface, there is a license notice: "This license maintenance expires December 01, 2008" and a footer: "For Help, press F1" and "Examiner".

3D Magnetics Inversion

3D Magnetism Inversion

$$d = F(m)$$

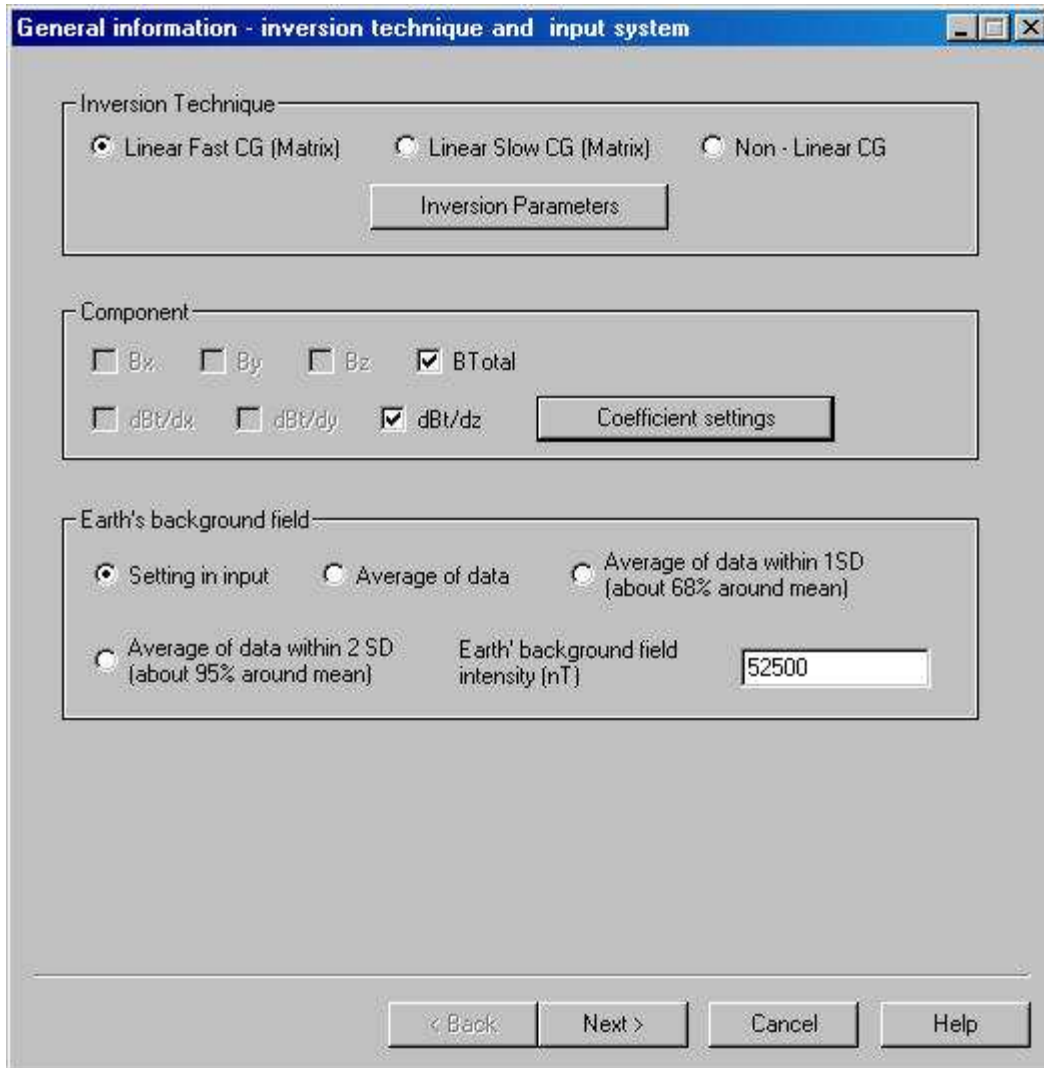
$d \rightarrow$ **data vector of dimension N**

$m \rightarrow$ **model vector of dimension M**

F - physical relationship describing the data as a function of the earth model - *In practice an approximation*

Approaches

- Linear Conjugate Gradient(Matrix)
- Non-Linear Conjugate Gradient



3D Mag Inversion

Linear CG Technique

Assumes that the forward function can be linearized. Quick technique but is bounded by solving for a small amount of parameters.

$$d = F m$$

$d \rightarrow$ vector of N - dimension
 $F \rightarrow$ Matrix of $N \times M$ - dimension
 $m \rightarrow$ vector of M - dimension

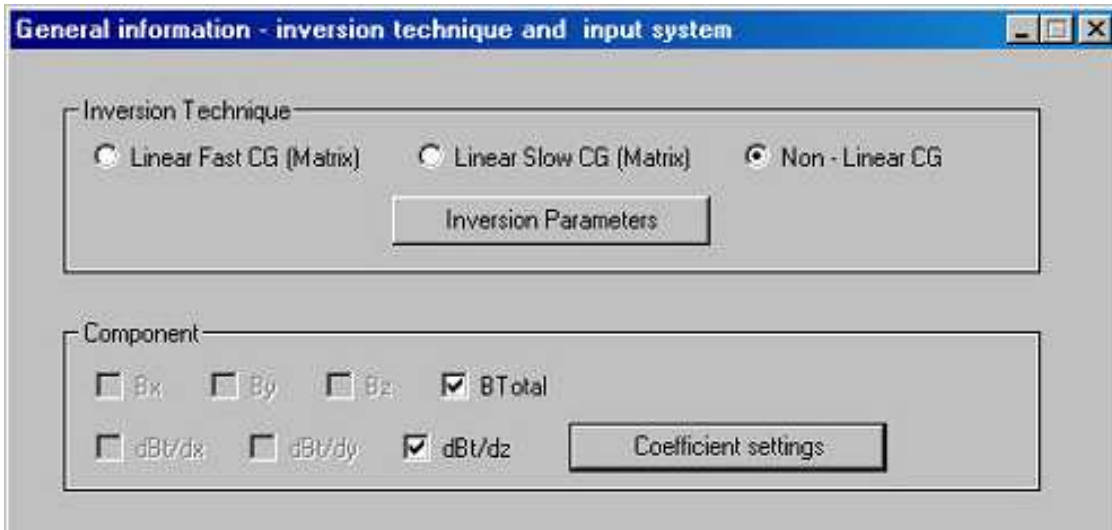
$$H_{\text{ext}}(r) = \int G(r, r') J(r') dr'$$

$$J(r') = (m(r') - m_0) H_{\text{ins}}(r') = \chi(r') H_{\text{ins}}(r')$$

Components Measured data will only have Btotal or total magnetic field. If you are inverting simulated magnetic data, you could chose to invert on the Bx, By, Bz or Btotal fields.

Earth's Background Field

You can use the background field value stored in the EMIGMA database or use an data average technique to obtain the value. You can use the magnetic susceptibility contained in your measured data survey, take an average of your data, take the average within 1 standard deviations or within 2 standard deviations. The earth's field is displayed. You can view the values by different methods before deciding which method to use



3D Mag Inversion

Non-Linear CG General

concept is to start with an initial guess and go looking for the best fitting model by minimizing a given function using an iteration process.

Critical factors to Optimization Results:

- Good forward simulation algorithm
- Good minimization technique
- Good starting model
- Good data

Occam style model misfit function

$$\phi_m(\mathbf{m}) = \alpha_0 \int w^2(\mathbf{z}) [\mathbf{m}(\mathbf{r}) - \mathbf{m}^0(\mathbf{r})]^2 d\mathbf{v} +$$

$$\sum_{i=x,y,z} \alpha_i \int [w(\mathbf{z}) \nabla_i (\mathbf{m}(\mathbf{r}) - \mathbf{m}^0(\mathbf{r}))]^2 d\mathbf{v}$$

α_I - weighting factors

$w(\mathbf{z})$ - depth weighting

Unconstrained Conjugate Gradient Minimization

Uses the derivative information to construct two sequences of orthogonal vectors to define the search direction at a given iteration. Then by trial and error (line search) to move to the local minimum in that direction. The iteration stops when the gradient has achieved the required minimum value. This is an unconstrained minimization technique where the bounds on the parameters are imposed after the search is completed.

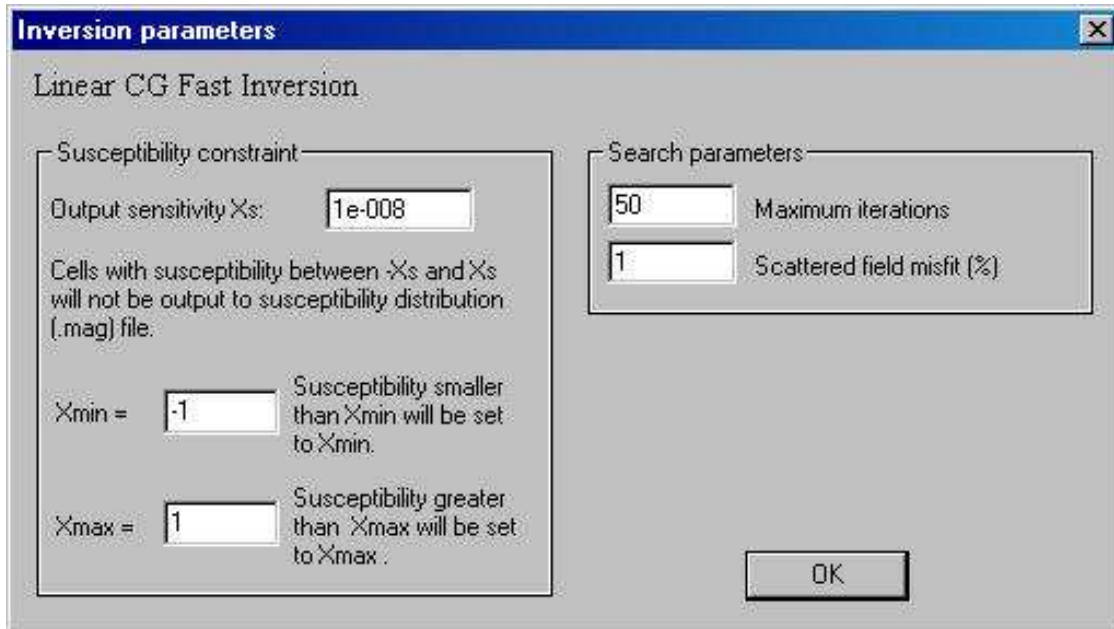
$$\phi(\mathbf{m}) = \lambda \phi_d(\mathbf{m}) + \phi_m(\mathbf{m})$$

$\phi(\mathbf{m})$ - functional to be minimized

$\phi_d(\mathbf{m})$ - data misfit

$\phi_m(\mathbf{m})$ - model misfit

λ - Lagrangian multiplier - regularization weight



3D Mag Inversion

Search Parameters

Maximum Iterations User defines the number of iterations the program will run to generate the final solution. In general the default (50 for Linear Fast CG and 30 for the others) is sufficient for the inversion.

Scattered field misfit

Defines the “stop” criteria for an iteration when the difference between the measured and scattered field falls within a certain percentage of the measured value.

Susceptibility Constraint

Output Sensitivity Cells with susceptibilities $|X|$ (close to 0 - where the user defines how close) are constrained or thrown out after each iteration. will not be output to the susceptibility distribution (.mag) files

Xmin Upon completion of iteration, X values less than Xmin will be set equal to Xmin

Xmax Upon completion of iteration, X values greater than Xmaz will be set equal to Xmax

3D Mag Inversion

General information - Earth's background field, input data and components

Earth's background field

Get from the first input Get from the second input

Method to obtain

setting in input Average of data Average of data within 1SD (about 68% around mean)

Average of data within 2 SD (about 95% around mean) Earth's background field intensity:

Input data for inversion

Number of locations in the selected survey area:

Maximum survey area

<= x <= <= y <=

Selected survey area to get data for inversion

<= x <= <= y <=

Components

Bx By Bz BTotal

Method to Obtain You can use the magnetic susceptibility contained in your measured data survey, take an average of your data, take the average within 1 standard deviations or within 2 standard deviations. The earth's field is displayed. You can view the values by different methods before deciding which method to use.

Input data for Inversion

Survey Area The Maximum survey area displays the x and y boundaries of your survey. To use the whole survey area, accept the default Selected survey settings. You can make the area smaller or larger by changing the x and y boundaries. The Number of locations or data points in the selected survey is displayed for you.

Components Measured data will only have Btotal or total magnetic field. If you are inverting simulated magnetic data, you could chose to invert on the Bx, By, Bz or Btotal fields.

General information -- Inversion search volume and grid

Inversion search volume

Use percentage of the input survey area: 120%

A .mag file A dataset User defined

File name:

Thickness Z (m): Horizontal Euler Angle (degree):

Grid for Inversion

Number of sub-volumes: Total number of grid points (cells):

Cell size X: Cell size Y: Top cell thickness Z:

Use topography information

3D Mag Inversion

Inversion Search Volume

Use percentage of the selected survey area This allows you to select a survey area greater, equal to or less than your survey area. If, for example, you have some edge anomalies, you may want to select a search area larger than your original survey. If you set your area to 125%, it will select a volume 25% larger than your survey.

User defined provides an interface that allows you to define the search volume.

Thickness Z(m) Define the depth of investigation.

Horizontal Euler Angle Allows you to define the strike of your survey

Grid for Inversion

The inversion tool will solve for the number of grid points displayed here. The grid cell size is also displayed.

Set Grid You can define the grid cell resolution by selecting this button

Use topography information This option will be enabled if you imported your data with a gps z channel. Select this option and the gps z values will be used when performing the inversion. When loading inversion results to the visualizer, a window will appear asking to display the survey according to Z or GPS Z. Select GPS Z to see the inversion results with topography.

Set grid for inversion search volume

Inversion search volume size:

X(m): 2400 Y(m): 1290 Z(m): 645

Total number of sub-volumes: 1 Total number of grid points: 486

Number of grid points for each sub-volume:

along X direction (Nx): 18 along Y direction (Ny): 9

Cell size X: 133.333 Cell size Y: 143.333

along Z direction:

Evenly spaced grid

Exponentially spaced grid (based on 2)

Vertical points (Nz): 3 Thickness of top cell: 92.1428

OK

3D Mag Inversion

Inversion Search Volume Size

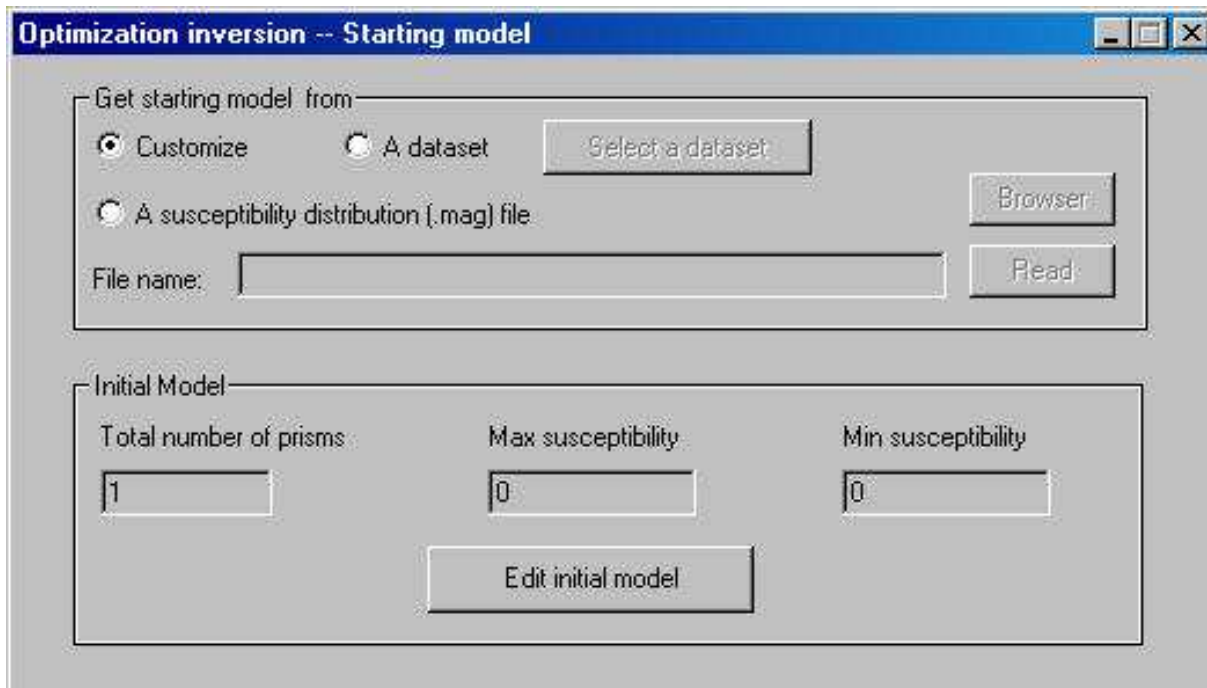
Displays the X, Y and Z dimensions of the search volume.

Z(m) = You can reset the depth of investigation here.

Number of grid points for each sub-volume

User defines the number of grid points to invert for along the X (Nx), Y (Ny) and Z (Nz) direction. Z grids can be either equal thickness (evenly spaced) or increase exponentially in thickness. Whichever method is chosen, the thickness of the top cell is displayed.

Once you have defined the grid point at the bottom, the total number of prisms and the total number of grid points are displayed.



3D Mag Inversion

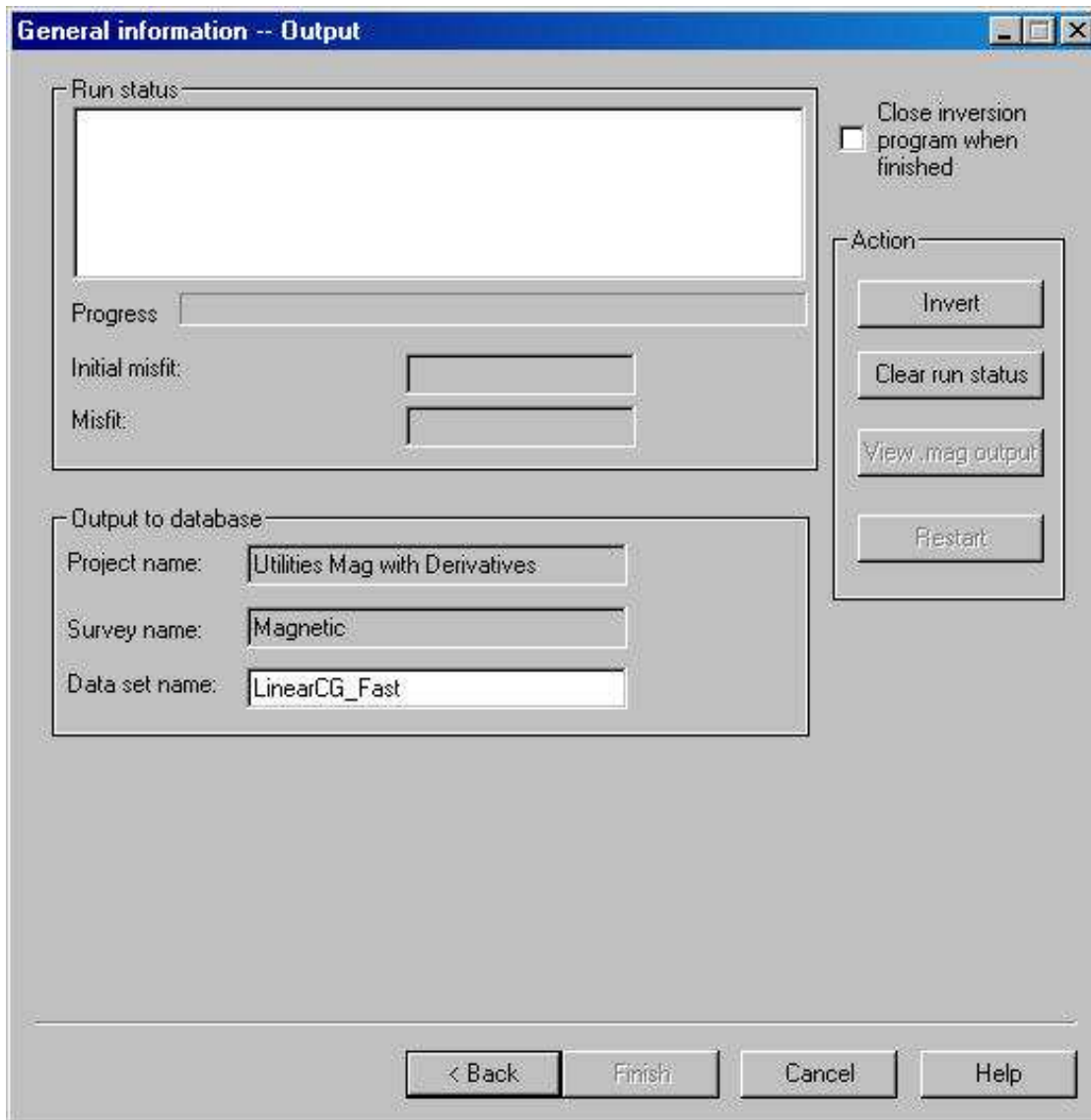
Starting Model

You can define the starting model in one of four ways:

Customize - provides an interface that allows you to define the starting model.

A .mag file – Allows you to browse for a magnetic susceptibility file from a previous inversion to use as your search volume.

A dataset – Allows you to browse for a data set (within the database) and you will have the choice of using the survey or a prism to define the search volume.



Invert When you are ready, you can select the Invert button.

Watch the inversion status in the Run Status window.

3D Mag Inversion

Run Status

Data set name Enter the prefix for the magnetic inversion output files xxx.

A susceptibility distribution file, xxx.mag will be generated and stored in the working directory. This file contains a distribution of anomalies that generates a magnetic field that matches your data with a certain fit.

You can use the .mag file to define the search area or the starting model in a future inversion.

Clear run status Empties the contents of the Run Status window


View .mag output Displays the raw inversion output file

Restart Returns the user to the first page so a new inversion can be performed

General information -- Output

Run status

```
Final Data-Misfit (*) = .6798E-05
Final Grad_Data_Misfit = 110.5
(*) Data Misfit is Normalized by "Zero Model" Misfit
...Terminating Matrix Inversion
Write data to database...
...End of Process
```

Progress 

Number of susceptible cells:	35
Initial misfit:	1.0000
Final misfit:	0.0000
Final gradient misfit:	110.5000

3D Mag Inversion

Initial Misfit A parameter that defines how close the initial model fits the measured data. The closer the value to 0, the better the fit.

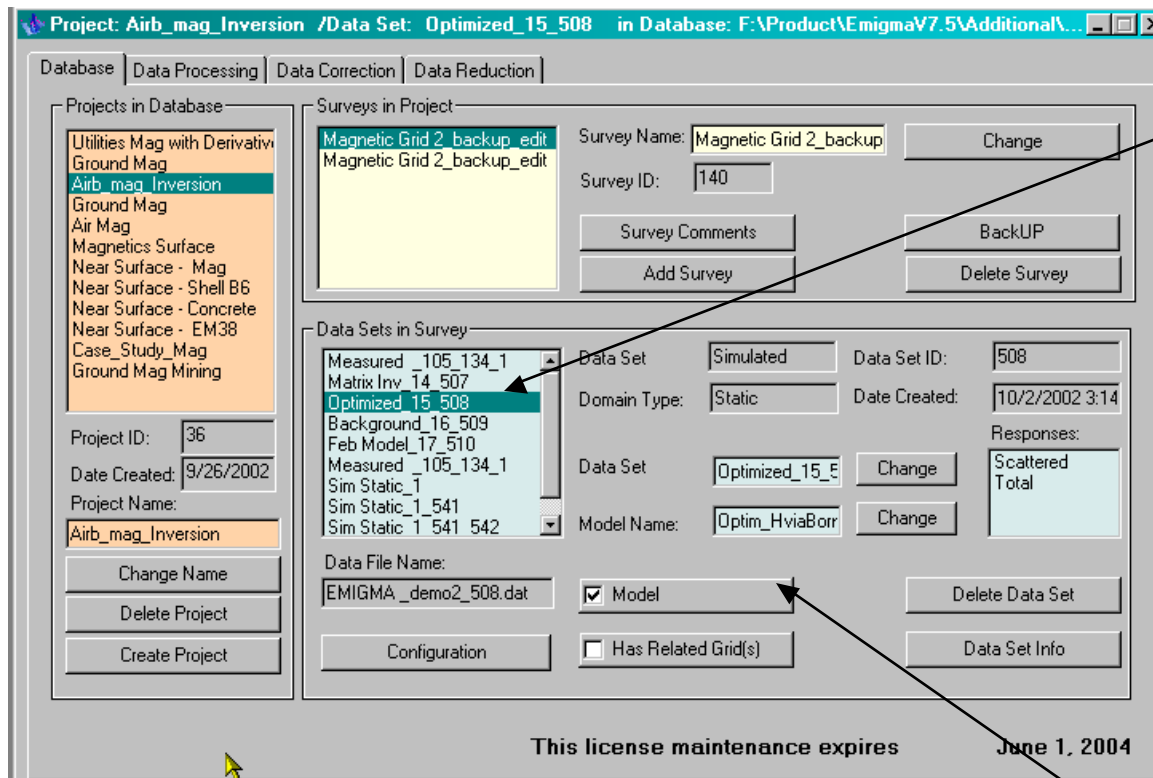
Misfit

A parameter that defines how close the final model fits the measured data. The closer the value is to 0, the better the fit.

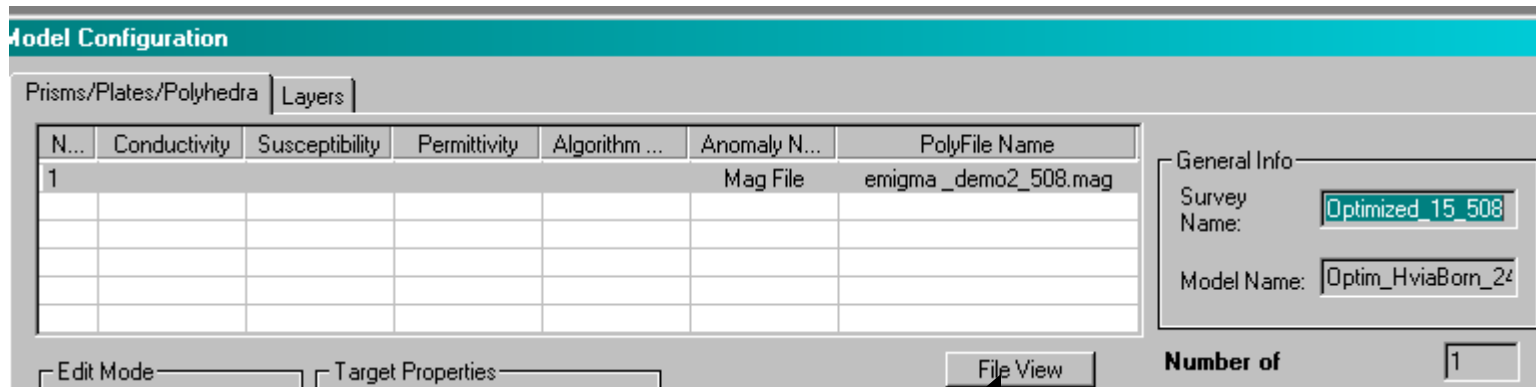
Upon successful completion the message "...End of Process" will be displayed and the progress bar will have reached the end.

Attached to the survey after inversion is a new dataset. This dataset contains the synthetic data under the inversion. Thus, the inversion creates a model which estimates the structure of the ground and this model has Simulated data associated with it.

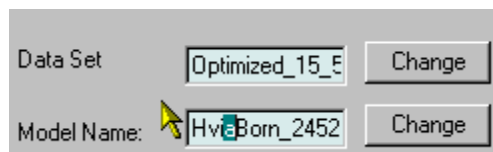
One may load this synthetic data with Measured data to a variety of applications such as the plotter to compare the Measured data with the Simulated data under the model.



The model or inversion grid is attached to the Measured data in the same manner as a Forward model. This model may be loaded to either the Visualizer or the Contour application



Upon clicking on the Model button, and then selecting the Prisms/Plate/Poly tab, the user gets this display. Attached to the database is a *.mag file which is in the database directory. In this case, the model is contained in the file *emigma_demo2_508.mag*. *The model name is Optim_HviaBorn_2452. This is a default name from the inversion. The user may, of course, rename this on the main window.*



the *.mag file may be viewed directly or opened into virtually anything as it is simply ASCII columnar file

Number of Cells

The image shows two overlapping windows from a software application. The 'File View' window on the left displays a list of 2452 cells, each with 8 columns of numerical data. The larger window on the right shows a grid of numerical values, likely representing a field or simulation results. Arrows from external labels point to specific data points in both windows.

Cell ID	X	Y	Z	du	dv	dw	Other
2452	6854.593750	53459.000000	-733.3315	205.5556	209.5238	533.3320	.00000 .00000
	6854.593750	53459.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	53459.000000	-33.33325	205.5556	209.5238	66.66650	.00000 .00000
	6854.593750	53669.000000	-733.3315	205.5556	209.5238	533.3320	.00000 .00000
	6854.593750	53669.000000	-33.33325	205.5556	209.5238	266.6660	.00000 .00000
	6854.593750	53669.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	53669.000000	-33.33325	205.5556	209.5238	66.66650	.00000 .00000
	6854.593750	53878.000000	-333.3325	205.5556	209.5238	266.6660	.00000 .00000
	6854.593750	53878.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	53878.000000	-33.33325	205.5556	209.5238	266.6660	.00000 .00000
	6854.593750	54088.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	54088.000000	-33.33325	205.5556	209.5238	66.66650	.00000 .00000
	6854.593750	54297.000000	-333.3325	205.5556	209.5238	266.6660	.00000 .00000
	6854.593750	54297.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	54297.000000	-33.33325	205.5556	209.5238	66.66650	.00000 .00000
	6854.593750	54507.000000	-333.3325	205.5556	209.5238	266.6660	.00000 .00000
	6854.593750	54507.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	54507.000000	-33.33325	205.5556	209.5238	66.66650	.00000 .00000
	6854.593750	54716.000000	-333.3325	205.5556	209.5238	266.6660	.00000 .00000
	6854.593750	54716.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	54716.000000	-33.33325	205.5556	209.5238	66.66650	.00000 .00000
	6854.593750	54926.000000	-333.3325	205.5556	209.5238	266.6660	.00000 .00000
	6854.593750	54926.000000	-133.3330	205.5556	209.5238	133.3330	.00000 .00000
	6854.593750	54926.000000	-33.33325	205.5556	209.5238	66.66650	.00000 .00000

X, Y, Z centre of each cell

Cell Size – du, dv, dw

3 Euler Angles

Cell K value

Technical Documents Included on your EMIGMA CD-ROM is a suite of tutorials, Power Point presentations, technical abstracts, newsletters and manuals. Most of these materials will be copied to your machine during installation. Others can be copied manually or referred to on the CD at any time.

*.\emigmav8.x

\manual

\tutorials

\technical

These files are also available by clicking on the EMIGMA Documentation link at <http://www.petroseikon.com/resources/newupdates.php>

Technical Support

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Feedback Your comments and feedback are always welcome and are helpful in making a better product for all users.

www.petroseikon.com