

3D GRAVITY INVERSION TUTORIAL

STEPS:

	Page
1. Import data to new or existing database	2
2. Examine data	5
3. Perform initial forward modeling	7
4. Perform 3D gravity inversions	8
5. Inversion Evaluation and Processing	19
6. Visualization	23
5. Inversion Evaluation and Processing	28
7. Export Models	32

- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization

EMIGMA Raw Data

7. E

Gravity Inverse 2

Browse and select .qct or .xyz data file for import - recommend .qct for easier use

visualization	
Export Models	Gravity import Step 1: Select a data file and set data setting
Import Formats	Input Data File D:\Product\Tutorial\DEPMO Gravity Isostatic TerrF Browser
Formats Other Sources	QCT format O XYZ ASCII format
Data Groups C EM Potential Field Potential Field Magnetotelluric IP/Resistivity DC Magnetics (ground, marine or airborne) - vector, TML of Gravity (ground, marine or airborne) - vector, TML of Gravity (ground, marine or airborne) - scalar or tensor Scintrex Ground Magnetics 3-Sensor Helicopter De-Rotated Magnetic Gradient Geosoft Grid File (Potential Field) Generic Borehole (magnetics and gravity) - vector, TML Crone (Borehole Magnetic) - vector	Station X:NAD27 Y:NAD27 Lat NAD27 Long NAD27 Elev NAD29 DEM_Elev DEMElev3 3001:00 677651:33 449:2027.6 40:561874 114:90:556 1988;259:000 1963:39:085 1965:6547932 1977.652:324 3004:00 677551:22 449:969.6 40:561825 -114:90:270 1970:877:000 1967:67932 1977.652:324 3004:00 677551:22 449:2019.0 40:561825 -114:90:335 1971:664:000 1965:564453 1973:770:752 Image: Comparison of the set of the
	G Gz Final C GTotal data unit: mGal
OK Cancel Set coordinate axes	Help 帮助 Gradierth refisor (mGal/m) Gxx Gxy Gyx Gyy Gyx Gyy Gzx Gzy Gzz Gzz
Select Data Channels	<back cancel="" help="" next="" td="" 帮助<=""></back>
	Click "Next " button

- 2. Examine data
- 3. Perform initi
- 4. Perform 3D
- 5. Inversion Ev
- 6. Visualization
- 7. Export Mode

Show profile inf

Users may perfe Delete/Reductio Operations in th

amine data	Profile and Locations Setting
rform initial modeling	
rform 3D gravity inversions	
version Evaluation/Processing	Total Number of Profiles: 14 Total Number of Locations: 614
sualization	
port Models	Profiles and Locations
profile information, may perform <i>(Reduction/Shift</i> ions in this dialog	Profile # Locations LiNE12125 45 LINE12175 29 LINE1225 45 LINE12200 45 LINE12200 45 LINE12600 45 LINE12600 45 LINE12800 45 LINE12800 45 LINE12800 45 LINE12800 45 LINE12800 45 LINE12800 45 LINE13000 45 LINE1300 45 LINE1300 45 LINE13300 45 Shift Coordinate Values Shift X 0
	Restore/Reset Shift Y O Change
Click "Next " button	< Back Next > Cancel Help

Gravity Inverse 3



2. Examine data

- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

1. Check database for the survey



2. Click configuration



4. Check profiles and stations with"Survey Editor"

3. Check system configuration









- 2. Examine data
- **3.** Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

Gravity Inverse 7

Note: *Performed some initial modeling to get a "feel" of the data and estimate parameters of initial model for inversion.*

Gravity Response





- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

Selected Data Sets

This confirms the dataset that has been loaded to the inversion.

<u>Components:</u> Components that will be used in the inversion are selected here. As an example, you might create derivatives through the Fourier tools and use one or more of these derivatives. In this case, the data indicates that the instrument measured the gravitational field in the vertical direction (*i.e. towards the Earth's centre*)

Selected dataset(s) to do inversion Inversion Method Dataset Survey Project Trust Region ROCKIES Non-Linear CG Measured Gravity SpruceMountain Gravity Is. Inversion Parameters Survey area information Component List Receiver Item Value Use Initial Model Gz Center East (m) 679048.86 Center North (m) 4490250.65 Size along lines (m) 4104.17 🔲 Use known geological structures Size across lines (m) 4722.20 Azimuth (Degrees) 90.066 Average Distance Between Locations (m) 100.22 Average Distance Between Lines (m) 545.83 Average Instrument Altitude (m) 0.30 Use topography Set Number of Locations Selected 319 information Search Volume 4490250.65 679048.85 Vertical Shift of Grid (m) 0 Center East Center North Remove Grid Cells 6000 Size V 6500 Size U 887.969 Distance (m) Select Search Area 90.07 2000 Azimuth (degrees) Thickness Grid Cell Settings (along grid axis) Inversion Messages Total 45240 13 Cells in Z 58 Cells in H Cells in V 100 500 Cell Size H Ton cell thickness Spacing Z direction $\Delta 2^{i-1}$. 🕞 Cell Sampling Δ_i Define Obtain Settings From a Log File Initial model misfit Progress Close application when inversion Help 帮助 <u>C</u>ancel Run completes

Log File: A log file is created each time an inversion is run. Use **Obtain Settings From a Log File** to load settings from a previous inversion. The log files are numbered according to Project/Survey/Dataset numbers.

<u>Use topography information:</u> This option will be enabled if you imported your data with a GPSZ channel. Select this option and by default the GPSZ values will be used for absolute elevation when performing the inversion with the Z(altimeter) channel providing the height above ground level. If you have a topography model imported to the database, you may use this for the topography information. [SET]. Note 1: When loading inversion results to the Visualizer, a window will appear asking to display the survey according to instrument altitude (Z) or GPSZ. Select the latter to see the inversion results with topography. Note 2: the GPSZ can be the elevations relative to the ellipsoid or the geoid.

<u>Remove Grid Cells</u>: Any cells that are beyond the specified **Distance** from the closest data point will be removed from the inversion grid prior to the inversion procedures.

<u>Geological Structure</u> : Click Use known geological structure to define a structure that will apply constraints to the inversion result.

Initial model misfit: Indicates how the initial model fits the data.

Gravity Inverse 10

1. Import data

- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

Clicking the **Select Search Area** button launches the window below. The "search area" implies the area in which the inversion algorithm seeks a model. You may also select a subset of the Survey area to be used in the inversion. However, we suggest extracting the desired subset from the original survey and saving the subset to your database to invert the subset.

<u>Display</u>: The interface display the data locations and their values according to scale. The horizontal distribution of cells is shown as a blue grid. The coordinates of the survey are shown on the axes.

📉 🐽 🚍 📰 🔁 🔍 🔍 🜌 ╈ East = 677965.93

Distance

From Left to Right:

- 1. Toggle data points ON/OFF, 2. Set size of data points,
- 3. Set Max/Min for data display, 4. Open a legend, 5. View all,
- 6. Zoom IN, 7. Zoom OUT, 8. Set aspect ratio Full screen or equal ratio

North = 4489248.03

9. Find a distance, 10. location of cursor, 11. Distance sought





- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

Grid Cell Settings

After exiting the previous dialogue, this portion of the interface is updated to summarize the previous settings.

If these are new inversion settings, a default thickness for the inversion grid is set as well as settings for the vertical divisions of the grid.

Vertical Grid Settings (Spacing Z direction)

There are 3 types of vertical divisions allowed: A) Uniform vertical gridding (Δ)m ; B) $\Delta \cdot 2^{i-1}$ for exponentially spaced cells and C) specify custom vertical cells, Δ_i . Your custom settings can be later modified by clicking **Define**.

tal thickness		5000	— Top De	epth
tal thickness after r	nodification	4885	0	
earch grid cell thic	kness			
Index	Thickness	Bo	ttom Depth	
1	5.0000		-5.0000	_
2	5.0000		10.0000	
3	5.0000		15.0000	
4	10.0000		25.0000	
5	10.0000		35.0000	
5	10.0000	. · ·	45.0000	
0	10.0000		-35.0000 CE 0000	
9	10.0000	· · · ·	.75.0000	
10	10.0000		85,0000	
11	20,0000		105.0000	
12	20.0000		125 0000	<u> </u>
Thickness (m)	10	Insert I	ndex	10
Modify th	e selected		Insert a thickne	ess
	Delete th	ne selected		

Other Settings

Total number of cells in the inversion grid is displayed beside "Total".

Cell Sampling:

During an inversion process, at each iteration, data is simulated for the present model iteration and model gradients are also computed. These computations are integrals over the grid densities of the present iteration. This process, to be accurate, is also an integration over each grid cell. The contribution of the mass of the cell at an observation point is not simply the mass of the cell assumed to be at one point (e.g. centre). The concept of most inversions, when computing the forward model, is to represent the mass of each cell at its center point. Here, however, you can improve these results by defining a grid over each cell for the contribution of each cell.

			Gra	wity Inverse 11
Search Volume				
Center East 679048	Center North	4490250	Vertical Shift of Grid (m)	0
Size U 6000	Size V	6500		
Azimuth (degrees) 91	_ Thickness	2000	Select Search Area	
Grid Cell Settings (along grid axis)				
Cells in U	Cells in V	Cells in Z	58 Total 45	240
Cell Size U 100 (iell Size V 500	Top cell thickr	ness 1	
Spacing Z direction C A	C ∆:2 ⁱ⁴ ⊙	Δ; Define	Cell Sam	pling
Spacing Z direction C A	© ∆·2 ^{i+I} ●	A; Define	Cell Sam	pling

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models



Inversion Methods

One comment should be first made here. For most present day geophysical inversion processes designed for the PC, inversion techniques can be described as "hunt and peck" techniques. The inversion operator is not linearized as in a classical definition of inversion. Rather the inversion, moves along one parameter to reach a minimum and then moves to another parameter and so on. How they minimize along each parameter is defined by some optimization technique such as Conjugate Gradient.

EMIGMA's inversion algorithms are more traditional in order to a) utilize fully the non-linear operator that is defined by the physics to relate the data to the earth's material properties , b) utilize the full memory capacity of each computer and c) utilize the multi-core processing units.

Trust Region (Matrix) - Direct inversion technique that uses the physical matrix operator. This technique utilizes a modified Trust Region inversion approach. Constrained inversion technique.

Non-Linear CG – This is a more standard technique used in geophysics today. The general concept is to start with an initial guess and then search for the best fitting model by minimizing a given function using an iteration process.

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

- 1	nversion Method
	Trust Region
	Non-Linear CG
	h
	Inversion Parameters

Non-Linear CG

The general concept is to start with an initial guess and look for the best fitting model by minimizing a given function using an iterative process.

Critical factors to Optimization Results:

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

Unconstrained Conjugate Gradient Minimization

This technique 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.

$$\phi(m) = \lambda \phi_d(m) + \phi_m(m)$$

$$\begin{split} \phi(m) &- \text{functional to be minimized} \\ \phi_d(m) &- \text{data misfit} \\ \phi_m(m) &- \text{model misfit} \\ \lambda &- \text{Lagrangian multiplier} \\ & \text{regularization weight} \end{split}$$

Occam style model misfit function

$$\boldsymbol{\phi}_{\mathbf{m}}(\mathbf{m}) = \boldsymbol{\alpha}_0 \int \mathbf{w}^2(\mathbf{z}) \left[\mathbf{m}(\mathbf{r}) - \mathbf{m}^0(\mathbf{r}) \right]^2 d\mathbf{v} +$$

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

 α_{I} - weighting factors w(z) - depth weighting

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

nversion parameters		×
Trust Region Inversion		
Constraints of density (g/cm^3) Sensitivity of the output density Ds	Search parameters	80
Cells with density between -Ds and Ds will not be output to density distribution (.grv) file.	Misfit (≋)	0.1
	Smooth parameters	
Density Bounds	Alpha s	0.3
Min 5 Max 5	Alpha x	0.5
L]	Alpha y	0.5
	Alpha z	0.5
<u>D</u> K	<u>C</u> ancel	Help 帮助

Constraints of Density (g/m³)

Ds : Sensitivity of output density:

Cells with density $|\rho|$ (near 0 as the user defines) are constrained or discarded after each iteration and will not be output to the density distribution (.grv) files.

Density Bounds:

Minimum and Maximum Density (g/cm³)

Inversion Parameters

Maximum Iterations

User defines the number of iterations the program will run to generate the final solution. In general the defaults are a minimum requirement.

Misfit (%)

Defines the "stop" criteria for an iteration when the difference between the measured and simulated data falls within a certain percentage of the measured value.

Smooth parameters

Larger values will increase the smoothness of the inversion result.

Alpha s decreases the overall range of the density values.

Alpha x, y and z decreases the difference between the density of two neighboring cells in the x, y and z directions respectively.

- 2. Examine data
- 3. Perform initial modeling

4. Perform 3D gravity inversions

- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

Initial Model

Click the checkbox labeled **Use Initial Model** to specify an initial model. Return to the initial model window by clicking the **Set Initial Model** button.

The starting model may be of two forms: a) a forward model previously developed containing either one or more prisms and/or polyhedra or b) a previous inversion model

nport a Model												
Project				Survey			Dataset	Note	: Only th	he datasets tha	t have model are	liste
Name		ID		Name		ID	Name		ID	Mod	el Name	Ŀ
ROCKIES		4		Gravity	_final_edit	1	m3		3	1	m3	Τ.
New Gravity Inst		3					m4		4		m4	
NEW GRAVITY Eikon		2					Model from Magnet	ic survey	5	Model from I	Magnetic survey	
Quebec ground Gravity		1					3DInv_TrustRegion		6	Trus	t_18951	
							ID341_Inv_Trust_(z	10	ID341_Tru	ust_14917_Gz	
							ID1_Inv_Trust_Gz		12	ID1_Trus	st_14917_Gz	
Name	Type		(g/cm	sicy 1^3)	(m)	(m)	(m)	Strike Leng (m)		Up Extent (m)	(m)	
Name	Туре		Dens	sity	Top X	Top Y	Top Z	Strike Leng	th	Dip Extent	Thickness	
Anomaly 1	Prism		1		668847.00	5371085.00	-50.00	900.00		400.00	150.00	-
anomary 1	1115111		-		000017.00	3371003.00	30.00	200.00		100.00	150.00	
1												
 ▲												
Note: Select the anomali	ies in the	lict t	o impo	ort								
vote. Delett the anomal	co in che	, iise e	o impo	<i></i>								
						7	Cancel	1			11-1- #	R R L
											Help #	別

Select the starting model:

The starting model must be within your present database. If it is not, import the dataset containing the desired model from the database in which it is contained. Then, select the Project, Survey and then the Dataset to obtain the model.

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

#	Dataset	Survey	Project	<u>Add</u>	Trust Region
1	Measured Gravity	Gravity_final_edit Qu	ebec ground Gravity		Non-Linear CG
				Weights	
					_ '
				<u>R</u> emove	Inversion Parameters
	and Link	Current aven information			
.ompone	Bacaivar		Value		
*		Center Eact (m)	469207.95		✓ Use Initial Model Set
⊻ 1	GZ	Center East (III)	5371346.96		
		Size along lines (m)	1731 19		
		Size across lines (m)	1508,91		Use known geological structures
		Azimuth (Degrees)	89.967		
		Average Distance Between Locations (m) 115.90		Set Structures
		Average Distance Between Lines (m)	593.23		
		Average Instrument Altitude (m)	0.47	•	
	Coofficient Softing				Use topography
	coencienc security		Number of Locations	Selected //	information
Center E iize U	East 668397.85054	Center North 5371346.96163 Size V 2000	Vertical Shift of Gri	id (m) 0	Distance (m)
Center E Jize U Azimuth	East 668397.85054 2500 (degrees) 89.968	Center North 5371346.96163 Size V 2000 Thickness 512	Vertical Shift of Gri Select Sear	id (m) 0	Remove Grid Cells Distance (m) 887.013
Center E Size U Azimuth Grid Ce	East 668397.85054 2500 (degrees) 89.968 ell Settings (along grid axis)	Center North 5371346.96163 Size V 2000 Thickness 512	Vertical Shift of Gri	id (m) 0	Remove Grid Cells Distance (m) Inversion Messages
Center E Size U Azimuth Grid Ce Cells ir	East 668397.85054 2500 (degrees) 89.968 ell Settings (along grid axis) n U 100 (Center North 5371346.96163 Size V 2000 Thickness 512 Cells in V 10 Cells in Z	Vertical Shift of Gri Select Sear	id (m) 0 rch Area Total 20000	Remove Grid Cells Distance (m) Inversion Messages
Center E Size U Azimuth Grid Ce Cells ir Cell Siz	East 668397.85054 2500 (degrees) 89.968 all Settings (along grid axis) n U 100 ze U 25 0	Center North 5371346.96163 Size V 2000 Thickness 512 Cells in V 10 Cells in Z Cell Size V 200 Top cell thick	Vertical Shift of Gri Select Sear 20 mess 2	id (m) 0 rch Area Total 20000	Remove Grid Cells Distance (m) Inversion Messages
Size U Azimuth Grid Ce Cells ir Cell Siz Spacin	East 668397.85054 2500 (degrees) 89.968 all Settings (along grid axis) - h U 100 ze U 25 ng Z direction C A	Center North 5371346.96163 Size V 2000 Thickness 512 Cells in V 10 Cells in V 200 Top cell thick C Δ·2 ⁱ⁺¹ O Δ _i	Vertical Shift of Gri Select Sear 20 mess 2	id (m) 0 rch Area Total 20000 Cell Sampling	Inversion Messages
Center E Size U Azimuth Grid Ce Cells ir Cell Siz Spacin	East 668397.85054 2500 (degrees) 89.968 all Settings (along grid axis) - n U 100 ce U 25 cg Z direction C A	Center North 5371346.96163 Size V 2000 Thickness 512 Cells in V 10 Cells in Z Cell Size V 200 Top cell thick C ∆·2 ^H C ∆ ₁ Define Obtain Settings From a Log File	Vertical Shift of Gri Select Sear 20 mess 2	id (m) 0 rch Area Total 20000 Cell Sampling	
Center B Size U Grid Ce Cells ir Cell Siz Spacin	East 668397.85054 2500 (degrees) 89.968 all Settings (along grid axis) h U 100 ze U 25 ug Z direction C A	Center North 5371346.96163 Size V 2000 Thickness 512 Cells in V 10 Cells in Z Cell Size V 200 Top cell thick C Δ·2 ⁱ⁺ C Δ _i Define Obtain Settings From a Log File	Vertical Shift of Gri Select Sear 20 sness 2	id (m) 0 rch Area Total 20000 Cell Sampling	Remove Grid Cells Distance (m) Inversion Messages Initial model misfit

• After all settings have been made, press $\underline{\mathbf{Run}}$ button to begin the inversion process.

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

Executing the Inversion

#	Dataset					
	Datasot	Survey	Project	Add	Linear Fast CG (Matrix)	
	measured_Gz	Gz_Inversion	Gz_Inversion	Sector Sectors	Non-Linear CG	
				weights		
				<u>R</u> emove	Investigation Processing	
	int	Current area information				
H I	Receiver) (stup	-		
<u>" </u>	Gz	Center X (m)	12712.5000	-	🗖 Use Initial Model	
		Center Y (m)	10450.0000		Set Initial Model	
		Size X (m)	1175.000			
		Horizontal Angle (Degree)	90.000 90.225		Use known geological structure	
		Average Distance Between Loc	ations (m) 25.000			
		,			Set Structure	
Coe	fficient Setting	Select :	Survey Area			
					Use topography information	
arch Volum	e					
Center X (m)	12712.5	Center Y (m) 10450	T op Z (m)	0	Remove Grid Cells	
					Distance (m)	-
iize X (m)	1300	Size Y (m) 140	00 Thickness (m)	650	Distance (m)	
torizontal A Inti-clockwi	ngle (degree) se from East	90 Selec	t Search Area	Cell Sampling		
					Inversion Message	
Grid Settin] S				Data Misfit 4.37%	
Cells in X	Cells	in Y Cells in Z	Total	_	Iteration 19	
46	13	6	3588		Data Misfit 4.28% Least Souares Misfit 3.3324	
Spacing Z	direction		The call this has a f		Iteration 20	
opacing z		. O ∆:2 ⁱ⁺ⁱ O ∆ _i Def	ine i op cell (nickness (mj 108.333	Least Squares Misfit 3.2243	
					Recovering data Write data to database	-
				1	Initial model miefit	_
S	et Output Log File Name	e	Giet Settings From a Log File	:		
						-

The window on the right displays the inversion's progress.

The "Progress" bar indicates graphically the progress of the -inversion

- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- **5. Inversion Evaluation/Processing**
- 6. Visualization
- 7. Export Models

atabase: D: Product (Tutor atabase) Survey Review) Data Projects in Database Projects in Database ROCKIES New Gravity Inst New Gravity Inst New GRAVITY Eikon Quebec ground Gravity	Itals (EMIGMA\source_hies\V11.0\gravi	Survey Name: Gravity_final_edit Change
		Copy Survey Comments BackUP Paste Add Survey Delete Survey
Project ID: 1 Date Created: 5/25/2025 1:29:50 PM Project Name: Quebec ground Gravity Change Name Delete Project Create Project	Data Sets in Survey Measured Gravity m2 m3 m4 Model from Magnetic survey 3DInv_TrustRegion ID341_Inv_Trust_G2_SecFile ID11_Inv_Trust_G2_SecFile ID1_Inv_Trust_G2 Data File Name: InstituteDisrPrev_Demo_58.dat Configuration	Data Set Simulated Data Set ID: 58 Domain Type: Gravity Data Modified On: 5/31/2025 10:26:16 Data Set Name: Responses: ID1_Inv_Trust_Gz Change Model Name: ID1_Trust_14917_Gz Model Delete Data Set Grid(s) Data Set Info
		This license maintenance expires July 01, 2027

INVERSION EVALUATION

In each survey, there will be several data sets after forward modeling simulation, inversion and processing. In this case, we have the simulation data from 4 forward models, four inversion models and one set of cross sections from an inversion model. Each model simulation has a new data set containing the simulated data for the model attached to the data set. Similarly, each inversion contains a new dataset containing the simulated data set under the inversion model and attached to that data set is the inversion model.

Our 3D gravity inversion model dataset

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models



Inversion Processing

Gravity Inverse 19

There are a number of procedures for processing of the inversion results. These are common for all of the 2D/3D inversion applications. The export functions will be covered slightly later. At times it is desired to have the inversion results relative to depth below ground and at other times relative to the elevation datum.

Users can use "3D Inversion Model Processing" tool to a) remove cells in the inversion model and/or b) adjust cells in the model. The interface below displays the distribution of the chosen parameter within the cells. The range for this parameter is set for cell removal. After selecting the range for removal, click 'Apply' and the information will be updated. Additional removals may be made.



- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

3D Inversion			a 11 A
O 3D Gravity Inversion	then a new density a	for all the cells in the range is defined	y of cells. A ran d. <i>Apply</i> makes
O 3D Euler		Cell Removal	
C 2D Werner C Magnetization Vector Inversion	n	Quebec ground Gravity - Gravity_final_	_edit - ID1_Inv_Trust_0
3D Inversion Model Processing	9	Inversion File: institutedisrprev_dem Model: ID1_Trust_17410_Gz	o_59.grv Da
Select a processing tool from the list 3D Inversion Model Processing Convert between GPS Z and Z Export Depth Slices/Cross Section Export Inversion File		Y shifted by 5300000 # of Cells 17410 Minimum -1.177 g/cm3	Distribution of Va [-1.1770 [-0.555 [0.063
Impedance Data Set	wersion Model Processing	Maximum1.925g/cm3Top Depth543.5468Bottom Depth-487.343	[0.689 [1.328
Apply for Impedance Data only Select Exit	C Cell Removal	Modify ce Low Limit -1.177	lls in this range: High Limit 1.925
	Cell Adjustment	O Density	New -1.17
	OK Cancel		

Inversion Processing

Gravity Inverse 20

0.3905%

89.3968%

9.8161% 0.3044%

0.0919%

Help

There are a number of procedures for processing of the inversion results. These are common for all of the 2D/3D inversion applications. The export functions will be covered slightly later. At times it is desired to have the inversion results relative to depth below ground and at other times relative to the elevation datum.

lls. A range of densities is selected and ly makes the changes.

_Inv_Trust_Gz

ibution of Values

Data Set ID: 59

[-1.1770 , -0.5572]:

[-0.5559 , 0.0638]: [0.0639 , 0.6818]:

[0.6892 , 1.3030]: [1.3280 , 1.9250]:

More Detail

-1.177

Cancel

Save

Click "Apply" button when modify range is defined

One use of this functionality is adjust the resulting inversion in preparation to use the modified inverse model as a starting model for a further inversion.

Reset

Apply



- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization

m2 m3 m4

7. Export Models

Inversion Evaluation/Processing Export Functions

When an inversion result is selected and the user opens the 'Model' description an 'Export' option is provided.

	Inversion Model Processing	×
Data Sets in Survey	Select a processing tool from the list	
m2 m3 m4 Model from Magnetic survey 3DInv_TrustRegion ID341_Inv_Trust_Gz ID341_Inv_Trust_Gz_SecFile ID1_Inv_Trust_Gz ID1_Inv_Trust_Gz ID1_Inv_Trust_Gz ID1_Inv_Trust_Gz ID1_Inv_Trust_Gz ID1_Inv_Trust_Gz Model Name: ID1_Trust_17410_G; InstituteDisrPrev_Demo_59.dat ✓ Model	3D Inversion Model Processing 3D Inversion Model Processing Convert between GPS Z and Z Export Depth Slices/Cross Section Export Inversion File	
Model Configuration Prisms/Plates/Polyhedra Layers	×	
N Resistivity Susceptibility Density Algorithm Anomaly Name File Nam 1 Grav File Models/InstituteDisPre Edit Mode Target #: 1 Insert Target #: 1 Export	EXPORT OPTIONS: The first Export option Survey Name Dil_Inv_Trut_Gz Number of Models 1 Number of Models	on allows to extract Depth 1. The second option is to may be performed on either that you have produced.

Help 帮助

The cross sections are exported to a new dataset for viewing in our Section Viewer and can be exported from that app to standard formats. The user controls the depth slices (Number, Depth increment, etc) and the output is to a .qct file. From there it may be exported to an ASCII file if required.

N... Resistivity -Edit Mode • IN Number Resistivity(Ohm.m) O ILN 0.032 1st Conductivity C Poly C VH 0 2nd Permeabilit C Spher C ES 0 3rd Permittivity Susceptibility - Center/Top Location Scale Eactor (m) Convert Model to Poly Geological Angles-Density (g/cm^3) х 1000 Strike Length Strike 89.968 - [] 500 Dip Extent Cole - Cole 0 Dip Ζ C (exponent) Delete Plunge 0 Thickness dimensionles 🙆 Top C Center M (chargeability) T (time constant) 0 Restore Poly Filename seconds

OK

Cancel

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

INVERSION VISUALIZATIONS

Click <u>Viz</u> button to open Visualizer tool to view the inverted 3D model...

🛢 🌉 🕮 🛅 🖫 📁 🎜 🎾 🌩 🗲 📜 🕨 🕨 🏷 🏠 岱 🙊 🕂 🛛 Save to Database



You may export a 3D image as a 3D .pdf. File ► Save Image

Various controls are provided on the toolbar above the visualization scene. There is a tutorial on the use of the Visualizer both for viewing as well as building models.

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

VISUALIZATION

Select from top menu "Model ► 3D Inversion Model
► Model Cutting" to open the *Section Cutting* tool.



Gravity Inverse 24

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing

6. Visualization

7. Export Models

VISUALIZATION

Select from top menu "Model ► 3D Inversion Model
► Sensitivity" to open the *Sensitivity Selection* tool.



The model in this figure has only those cells exhibited with values specified in the range

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models



VISUALIZATION

Another visualization tool which interpolates the inversion grid into finer grid cells and allows other visualization capabilities



- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

VISUALIZATION

<u>**CROSS SECTIONS</u></u>: From the Model button, you may export cross sections. This function produces another dataset containing the model as density slices (*.gsc). These files may be viewed in the viewer indicated by PEX on the toolbar.</u>**

CDI VIEWER





- -The values of the abscissa are shown across the top. The abscissa may be changed.
- Depth is shown on the left axis. Double click on an axis to change the settings.
- The value of the perpendicular coordinate is shown on the left at the beginning of section and on the right at the end of the section
- The inversion data is shown initially without contouring. Click on a cell to view the depth and parameter value of the cell
- the box at bottom left of toolbar is the value of the center point for the coordinate perpendicular to the abscissa
- Use left right arrows to move between sections
- The small Data Plot window is the parameter value vs. depth for the selected point. Tools are at the bottom



- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- **5. Inversion Evaluation/Processing**
- 6. Visualization
- 7. Export Models

Database: D:\Product\Tutorials\EMIGMA\source_files\¥11.0\gravity tutorial\InstituteDisrPrev_Den					
Database Survey Review Data Correction Data Reduction					
- Projects in Database-	- Surveys in Project				
ROCKIES New Gravity Inst NEW GRAVITY Eikon Quebec ground Gravity	DEMO_Gravity_Isostatic_TerrFar SpruceMountain_Gravity_Isostatic_TerrFar SpruceMountain_Gravity_Isostatic_TerrFar	Survey Name: SpruceMountain_(Survey ID: 9			
		Corby Survey Co Paste Add Si			
	Data Sets in Survey				
	ID1438_Inv_Trust_Gz	Data Set Simulated			
Project ID: 4 Date Created:	ID1438_Inv_Trust_Gz_SecFile ID1438_Inv_Trust_Gz ID1438_Inv_Trust_Gz_SecFile	Domain Type: Gravity			
5/27/2025 9:40:49 PM	ID1438_Inv_1rust_Gz ID1438_Inv_Trust_Gz_SecFile	Data Set Name:			
Project Name:	ID1438_Inv_Trust_Gz ID1438_Inv_Trust_Gz_SecFile	ID41_Inv_Trust_Gz			
ROCKIES	ID1438 Inv Trust Gz	Model Name:			
		ID41_Trust_39840_Gz			
Change Name	Data File Name:	1			
Delete Project	InstituteDisrPrev_Demo_57.dat	lodel			
Create Project	<u>C</u> onfiguration	rid(s)			
	-	This license maint			

Inversion Evaluation

To assess how well the inversion model fits the data at each station, select the inversion data set and then select the plotter.



Load Data Set	:				x
?	Do you want to) compare with oth	er Data Sets?		
Yes	No	Load Settings	Cancel	Help	

Select "Yes", if this dialog appears and select all datasets that require comparison.

- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- **5. Inversion Evaluation/Processing**
- 6. Visualization
- 7. Export Models

Inversion Evaluation

Select the data sets required for comparison and then click "Load"

ata Sets Selection				
Project: New Gravity April 2025		Sur	vey: SpruceMountain_Gra	avity_Isostatic_TerrFar
Data Sets in Survey:	11		Selected Data Sets to	load: 3
Name	Model Name 🔺	Data Units:	Name	Model Name
ID1438_Inv_Trust_Gz ID1438_Inv_Trust_Gz_SecFile sediments small	ID1438_Trust_36 ID1438_Trust_36 sediments small	mGal	Measured Gravity ID1438_Inv_Trust ID1438_Inv_Trust	ID1438_Trust_44537_Gz ID1438_Trust_44734_Gz
ID1438_Inv_Trust_Gz ID1438_Inv_Trust_Gz_SecFile ID1438_Inv_Trust_Gz	ID1438_Trust_41 ID1438_Trust_41 ID1438_Trust_40	Add to>]	
ID1438_Inv_Trust_Gz_SecFile ID1438_Inv_Trust_Gz_SecFile ID1438_Inv_Trust_Gz	ID1438_Trust_40 ID1438_Trust_44 ID1438_Trust_44	Add All to>		
ID1438_Inv_Trust_Gz_SecFile	ID1438_Trust_44	< Remove from		
-Loading	Show IMPE	DANCE / MAGNETIC RATIO D	ata Sets in Survey	Load
Loaded 0	of 3			Cancel

All selected data sets are then loaded to the Plotter application and the plot appears showing the simulated data of the first profile. Use the left/right arrows to move between lines or double-click the plot.



- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- **5. Inversion Evaluation/Processing**
- 6. Visualization
- 7. Export Models

Inversion Evaluation

Gravity Inverse 30

The user may select other data sets to plot by simply double clicking on the plot or change parameters in the plot.



Gravity Response

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- **5. Inversion Evaluation/Processing**
- 6. Visualization
- 7. Export Models

Inversion Evaluation

Gravity Inverse 31

Multiple plots can be shown for various inversions and models contained in the same survey of the database. The user may step through different profiles by simply clicking the arrow and step through models using the arrows to the right of **M**.



Absolute Y (m)

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization

7. Export Models

	🗱 Export Inversion Model
20	Inversion Model File
3D Inversion	D:\withYang\CSEM Inversion Paper\CJES\CJES_db\Models\CJES_1456.grv
 3D Gravity Inversion 3D Euler 2D Werner Magnetization Vector Inversion 3D Inversion Model Processing 	Output Settings Top Grid Depth Min Distance Between Depths From Depth Thickness 2686.54 0.00100327 2686.54 14.035 Bottom Grid Depth Max Distance Between Depths To Depth nDepth -106.424 6.42334 106.424 200 No. of Unique Depths In Grid 42045 Use depths in the input file C Original File C Adapted CDI Ensitivity C Density
 Inversion Model Processing Select a processing tool from the st 3D Inversion Model Processing 3D Inversion Model Processing Convert between LPS Z and Z Export Depth Slides/Cross Section Export Inversion File 	Output qct File Dutput format © Depth Slices Qct file name Browse Processing Status Progress Progress 0% Save View Cancel Help

EXPORT OPTIONS:

Export Depth Slices/Cross Sections

<u>Depth Slices</u>: This tool provides slices of the densities in the grid at a set of depths. The default is to create an interpolated volume before slicing. The user specifies the top depth plane and the bottom depth plain and the number of Depths of the Thickness between each depth plane. Browse to specify a folder and a QCTOOL file name for export. The depth slices are easily contoured in QCTOOL or exported for import to another application.

EXPORT MODELS

xport Slices

Depth Slices

C Cross Section

Cancel

OK

<u>Cross Sections</u>: We have seen above how to export cross sections to another data set in order to use EMIGMA's section viewer. However, you may export the cross sections here directly to a QCTOOL file for export to another program.

Gravity Inverse 32

×

- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

EXPORT INVERSE MODELS to CAD FORMATS

The inversion grids can be imported to CAD applications but when integrating the inversion into a larger CAD project, a more compact form is often required. This is normally performed on a reduced inversion model which focuses on the most interesting structures in the inversion model. In the example below and to the left, is a view of the inversion model sliced at depth. The interesting structure can be seen in the upper left of the model. The image below shows the inversion model after removal of small values of inverted density.



Model Configuration							
Prisms/Plates/Polyhedra Layers							
N Resistivity	Susceptibility	Permittivity	Algorithm	Anor	nalu Name Tugʻi no	м	File Name lodels\King_Solomc
Edit Mode Insert Target Replace Target Import Target Limport Terrestory Convert Model to Poly	Target Pr Target # Target N Resistiv Conduc Permea Permitti Suscep Density	operties	100 0.01 2 1 1 1 0		Model Prisr C BiKF C Poly C Sphi Center/T X	Ex n Nate ere	Scat. Algor.



The first step is to convert the reduced grid to a polyhedral model. Select '*Model*' again and the Model Configuration dialogue opens (*bottom left*), the user selects the inversion grid at the top and the selects 'Convert Model to Poly' on the left of the dialogue. A view of this poly model is seen below in the Visualizer. The polyhedra file is stored in the Polyhedron subdirectory of the database structure.



- 1. Import data
- 2. Examine data
- 3. Perform initial modeling
- 4. Perform 3D gravity inversions
- 5. Inversion Evaluation/Processing
- 6. Visualization
- 7. Export Models

EXPORT INVERSE MODELS to CAD FORMATS

All model primitives in EMIGMA including polyhedral models can be exported to several CAD formats. Now that the model is in a polyhedral format it may be so exported.

MODEL ► Export ►





Output		×
Anomaly inform	ation	
Туре	Poly	
Name	3D_Lonv	
– Output – – –		
Format	Vulcan ASC (*.asc)	
ronnac	AutoCAD DXF (*.dxf) GEMCOM TBI (*.tri)	
File name		
		Browse
,	,	
Status		
_		
Progress		
	Export Cancel	

Browse ► To select a directory and save the file for import to CAD. Most CAD applications allow any of these 3 formats.

