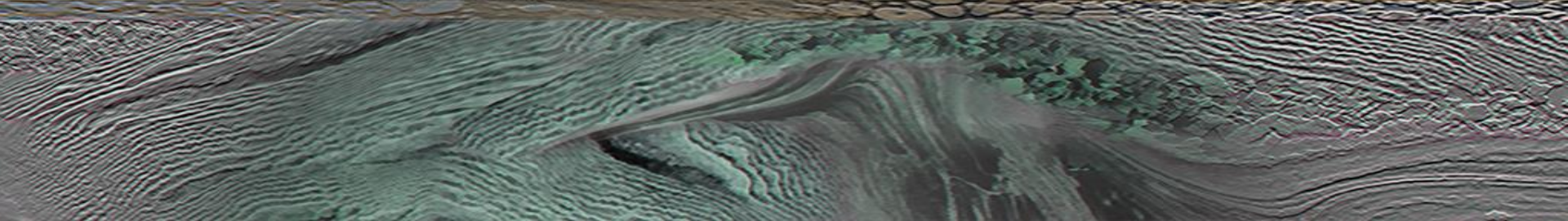


01 Jan 2000 (1 of 78)

CMG (IMEX) COURSE

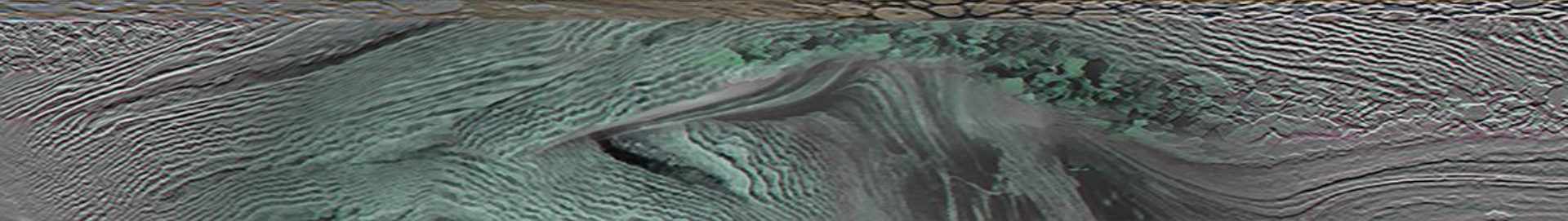
Instructor:

Mohammad Amin Gholamzadeh



Tutorial on CMG software installation





Creating a “Black Oil” Model using Builder 2006.10





Creating a “Black Oil” Model using Builder 2006.10

**Create a working directory somewhere on your disk and put
the map files that accompany this tutorial in this directory.**



Starting CMG Launcher

The screenshot shows the CMG Technologies Launcher window. The title bar reads "Technologies Launcher - Samples for Builder 2006.10 in C:\Program Files\CMG\BR\2006.10\TPL\Builder". The menu bar includes "File", "View", "Projects", "Programs", and "Help". Below the menu bar, there is a "Current Project:" dropdown set to "Samples for Builder 2006.10" and a "Show/Hide Job Scheduler" button. A toolbar with various icons is located below the project selection. The main area is divided into a "Directory Tree View" on the left and a "File List View" on the right. The directory tree shows a hierarchy starting with "Builder", followed by "Maps", "RESCUE", "Trajectories", "Waterflood Example", "Well Logs", and "Zmap Example". The file list view displays a table of files with columns for Name, Size, Type, Modified, Created, Accessed, and Attributes.

Name	Size	Type	Modified	Created	Accessed	Attributes
CMGBuilder00.dat	209 ...	DAT File	2017-05-20 21:48	2017-05-20 21:41	2017-05-20	A
CMGBuilder01.dat	78 KB	DAT File	2017-05-20 22:30	2017-05-20 22:28	2017-05-20	A
CMGBuilder02.dat	208 ...	DAT File	2017-05-21 09:30	2017-05-21 09:30	2017-05-21	A
cmgjournal.log	1 KB	Text Document	2017-05-21 09:30	2016-10-30 23:59	2016-10-30	A
cmgmsg.log	3 KB	Text Document	2017-08-07 12:08	2017-04-30 08:35	2017-04-30	A
cmgusage.log	15 KB	Text Document	2017-11-29 19:13	2016-11-20 22:20	2016-11-20	A
readme.txt	2 KB	Text Document	2001-04-19 15:43	2016-11-20 22:11	2016-11-20	RA

At the bottom of the window is a "Program Icons" view area displaying a row of icons for various applications: Builder 2006.10, CMG Journal Viewer, ECL100 Import Assistant, GEM 2006.10, IMEX 2006.10, License Monitor, Microsoft Excel, Microsoft Word, Notepad, Results 3D 2006.10, Results Graph 2006.10, Results Report 2006.10, STARS 2006.10, and WinProp 2006.10.

This window consists of the following areas:

- Main menu at the top.
- Project name and directory selection combo box.
- Toolbar and file filter combo box.
- Directory Tree View area.
- File List View area.
- Program Icons view area.



Starting CMG Launcher / Working with Projects

Adding a New Project

When you create a new project you can add it to an existing directory or create a new directory for that project.

To create a new project in an existing directory:

1. Select menu item **Projects**, then **Add Project** or click **Add Project icon** in the Toolbar.

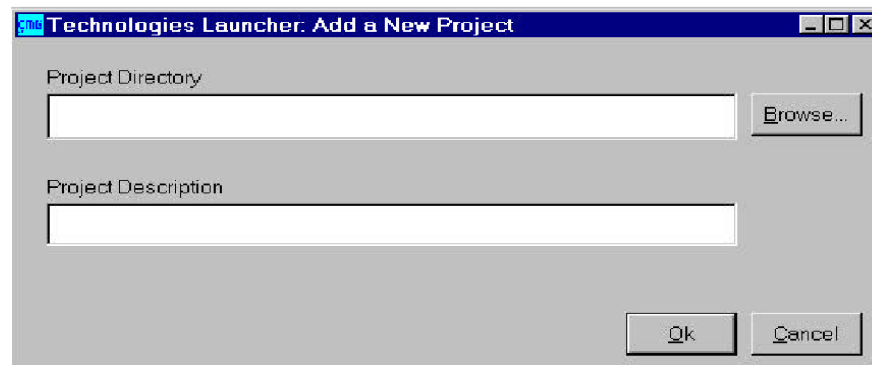


Add Project



Starting CMG Launcher / Working with Projects

2. The **Add A New Project** dialog box appears.



3. Specify the directory in which you want to create a project by clicking the **Browse** button to display a **Browse for Folder** Dialog.

4. In **Project Description**, enter a description of the new project. The description can be up to 40 characters long.

5. Click **OK**.

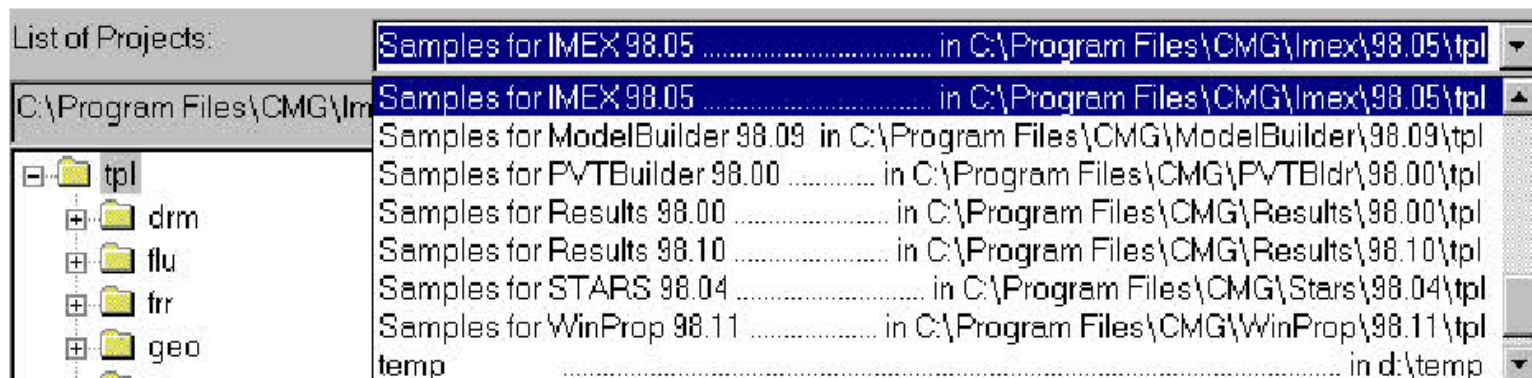


Starting CMG Launcher / Selecting a Project

Selecting a Project

To select a project:

Click the down arrow button of the **List of Project Combo box** to get a list of available projects with the associated directories and then click the desired project to select it.



Starting CMG Launcher / Removing a Project

Removing a Project

Once you have finished a simulation project, you may want to remove the project from the project list. When you remove a project it does not delete the directory from your hard drive.

To permanently delete a file, use the **DOS deltree** (Windows 95 only) command or the MS- Windows Explorer. You can also drag the folder to the recycle bin to permanently delete the directory.



Starting CMG Launcher / Removing a Project

To remove a project:

1. First select the project do be removed by following the above "Selecting a Project " procedure.
2. Select **Projects | Remove Project** menu or click **Remove Project icon** in the Toolbar. This will remove the current project from the project list.



Remove Project



Starting CMG Launcher / Modifying a Project

Modifying a Project

You may want to reuse an existing project and modify it for your needs.

To modify a project:

1. Select **Projects | Modify Project** menu or click **Modify Project icon** in the Toolbar.

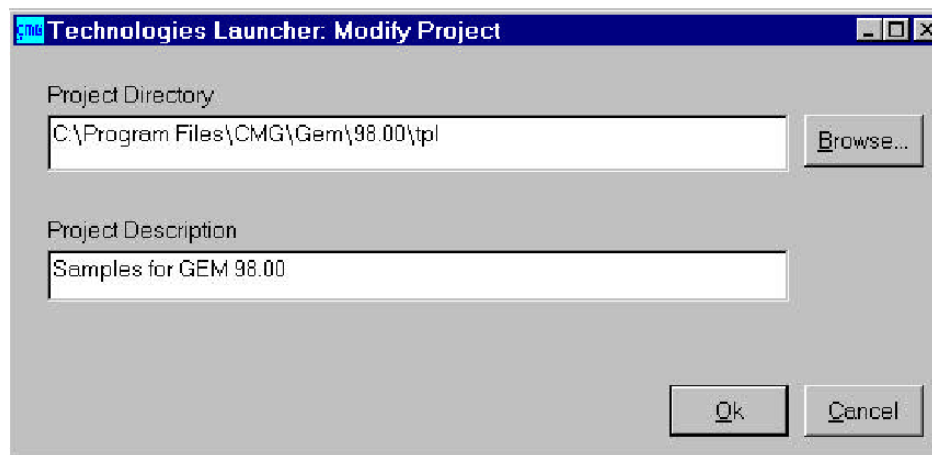


Modify Project



Starting CMG Launcher / Modifying a Project

2. Modify Project dialog appears.



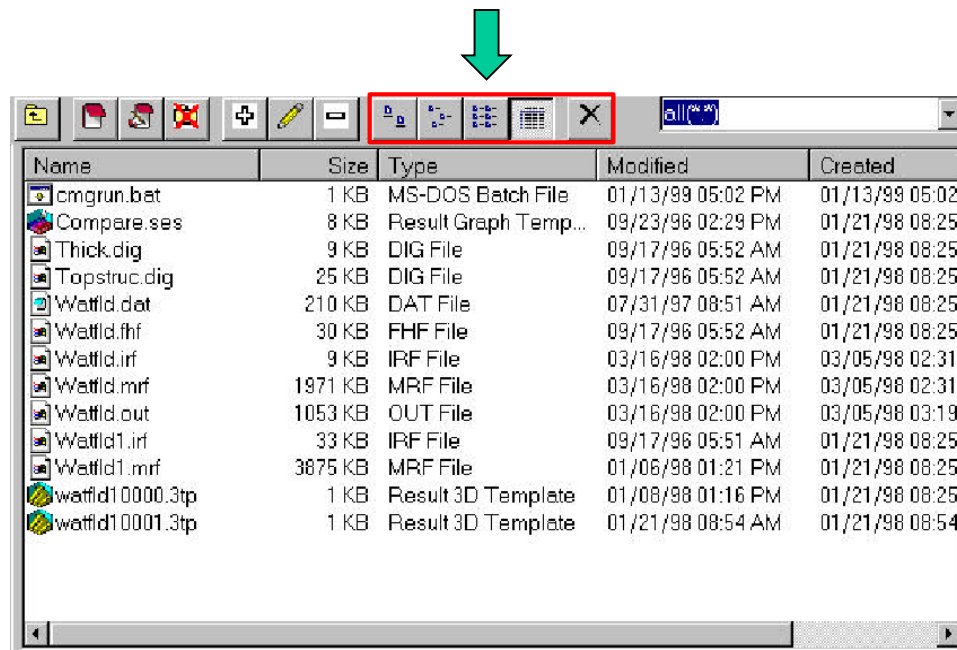
3. Use the Browse button to select a new directory. Or change the project description.

4. Click OK.



Starting CMG Launcher / Working with File List View

Working with File List View



This area displays the file list under the currently selected project or directory. The list is also filtered by the current file filter pattern.



Starting CMG Launcher / Working with File List View

Meaning of icons in the Toolbar related to file list view:



From **left** to **right**:

1. Large Icon view type.
2. Small Icon view type.
3. List view type.
4. Details view type.
5. Delete selected file(s).



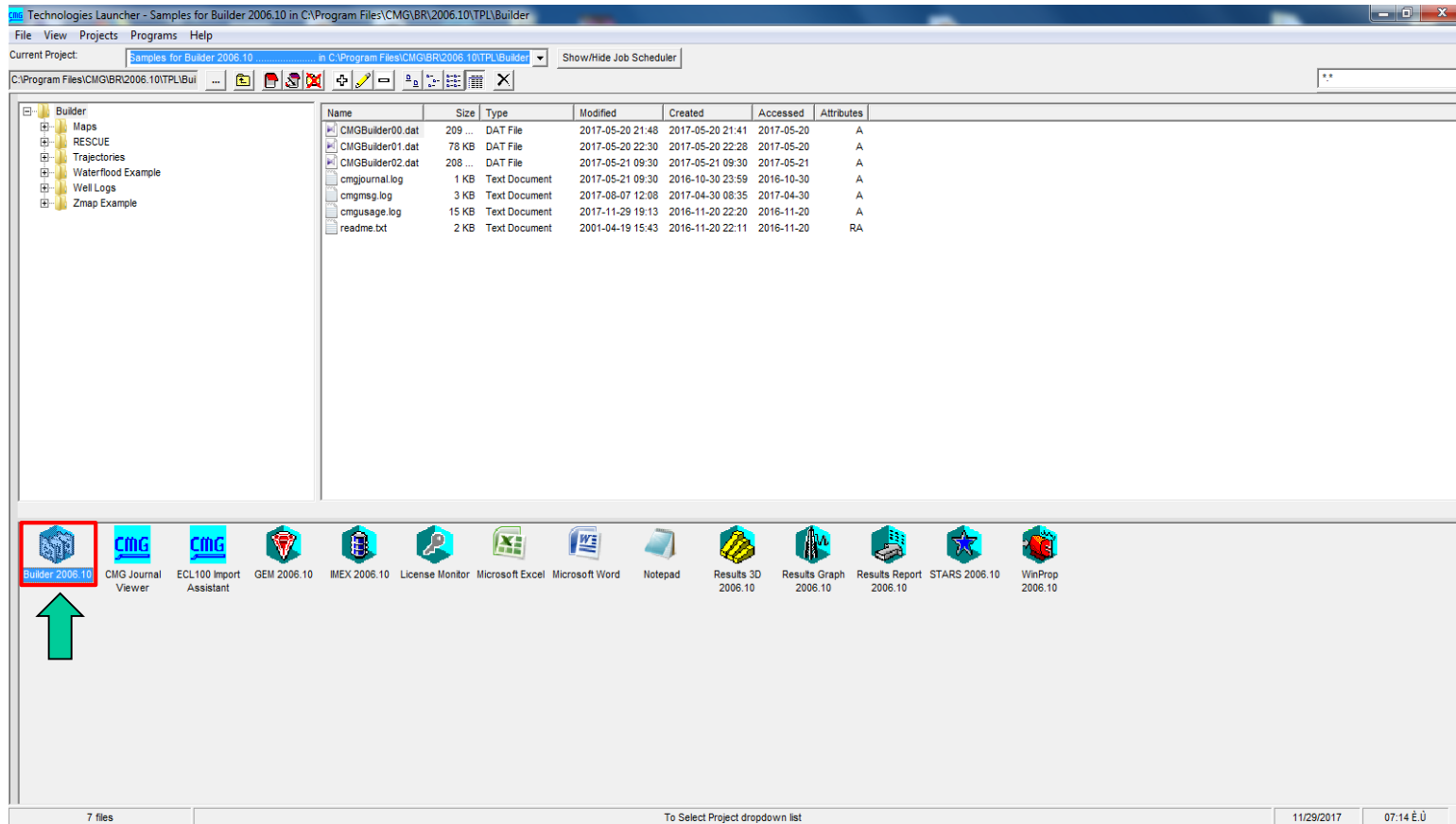
Starting CMG Launcher

Starting CMG Launcher

1. Start the **CMG Launcher** by using the icon on your desktop, or by going through the Start menu and selecting Programs/CMG/Launcher.
2. Select menu item **Projects**, then **Add Project**.
3. Browse for the directory where you stored the map files.
4. Call the project **Tutorial**.
5. Click **OK** to exit back to the Launcher.
6. You should now have this directory displayed.



Opening BUILDER 2006.10





Builder

Builder - Reservoir Simulator Settings

Simulator

- ☒ GEM
- ☐ IMEX
- ☐ STARS

Working Units

- ☒ SI
- ☐ Field
- ☐ Lab
- ☐ MODSI

Advanced...

Porosity

- ☒ Single Porosity
- ☐ DUALPOR
- ☐ DUALPERM
- ☐ MINC
- ☐ SUBDOMAIN

Shape Factor

- ☐ Gilman and Kazemi
- ☐ Warren and Root

Subdivisions for Matrix Blocks

Number of subdivisions:

Volume fractions
(2 values expected):

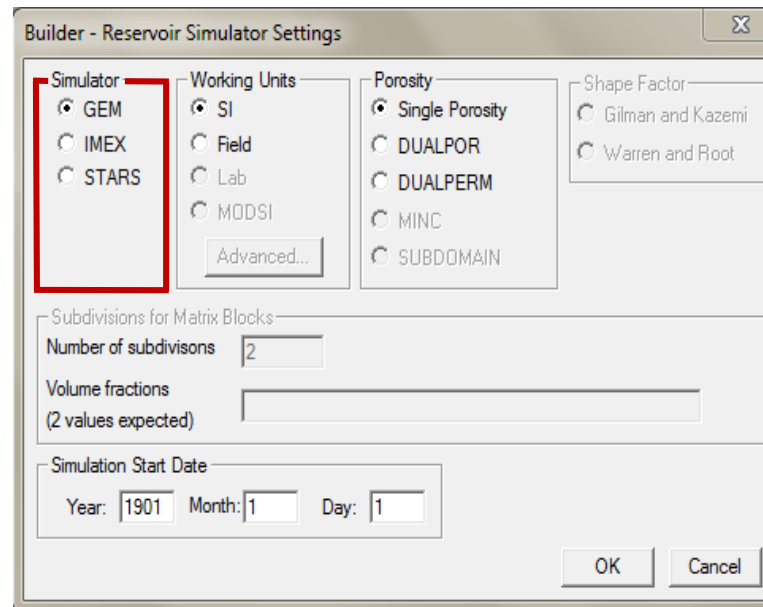
Simulation Start Date

Year: Month: Day:

OK Cancel



Builder/ Simulator

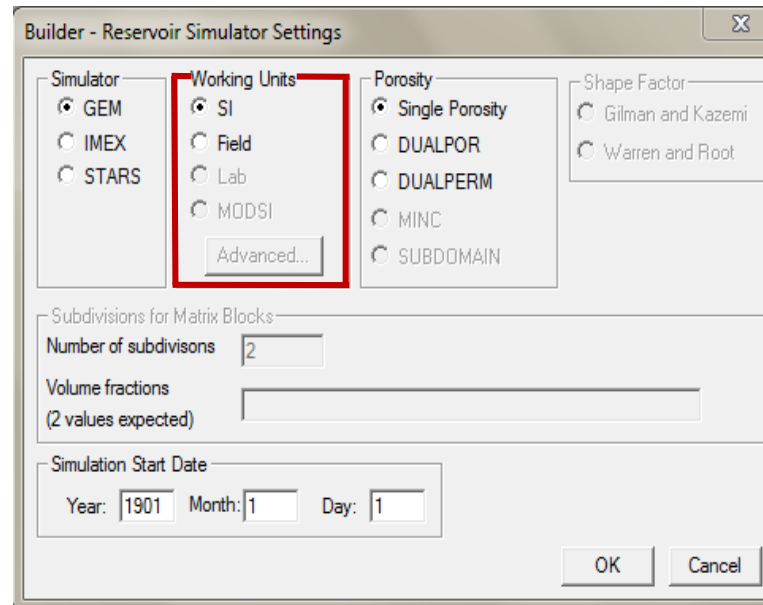


Select the appropriate simulator according to the type of simulation.

1. GEM (Compositional- Temperature changes are not considered.)
2. IMEX (Conventional Black Oil- Temperature changes are not considered.)
3. STARS (Compositional- Temperature changes are considered.)



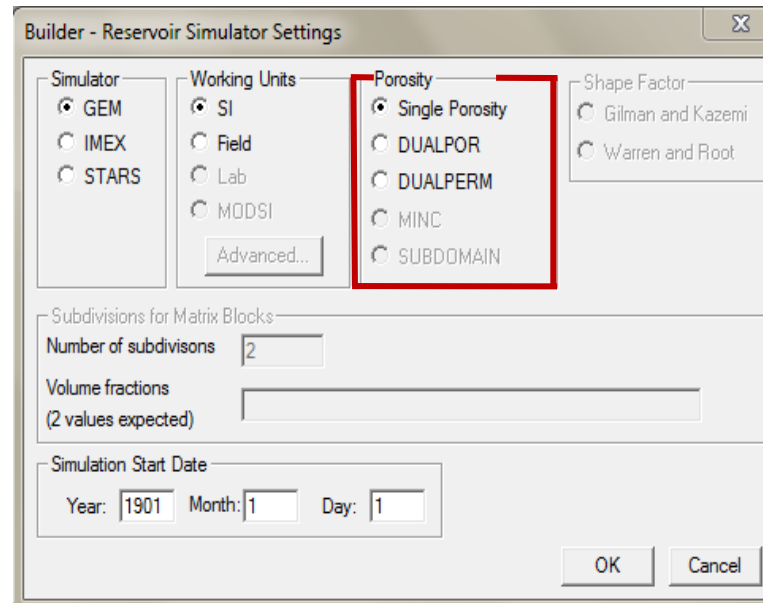
Builder/ Working Units



1. SI (International System of Units.)
2. Field (Oil Field Unit)
3. Lab (Laboratory Unit)
4. MODSI (Modified SI)



Builder/ Porosity



1. Single Porosity
2. DUALPOR (Dual Porosity)
3. DUALPERM (Dual Permeability)
4. MINC (Multiple Interacting Continue)
5. SUBDOMAIN



FRACTURED RESERVOIR

Fractured Reservoirs

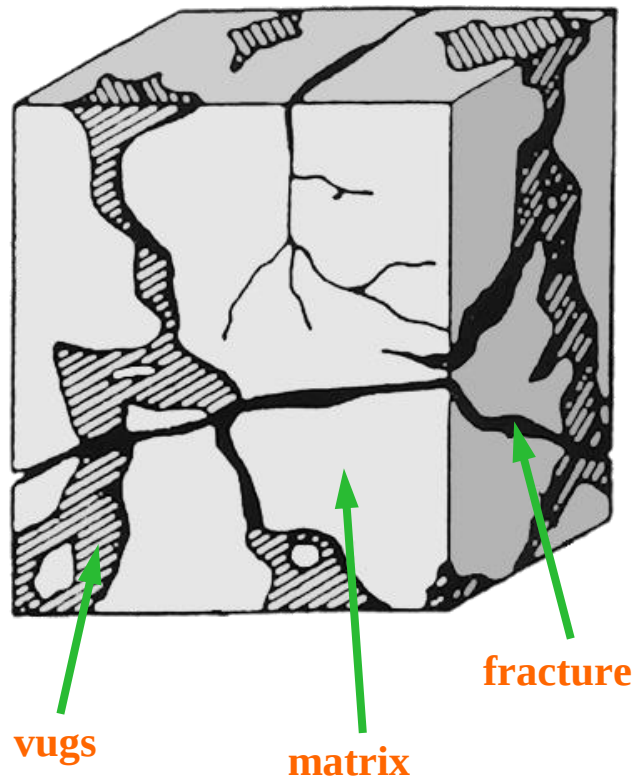
The simulation of naturally fractured reservoirs can be conducted through the use of **dual porosity models**. In these models, the reservoir is discretized into two collocated continua (two sets of grid blocks located in the same space), one called the **matrix** and the other called the **fracture**.

The matrix continuum is assumed to be comprised of matrix blocks which are separated spatially by fractures.

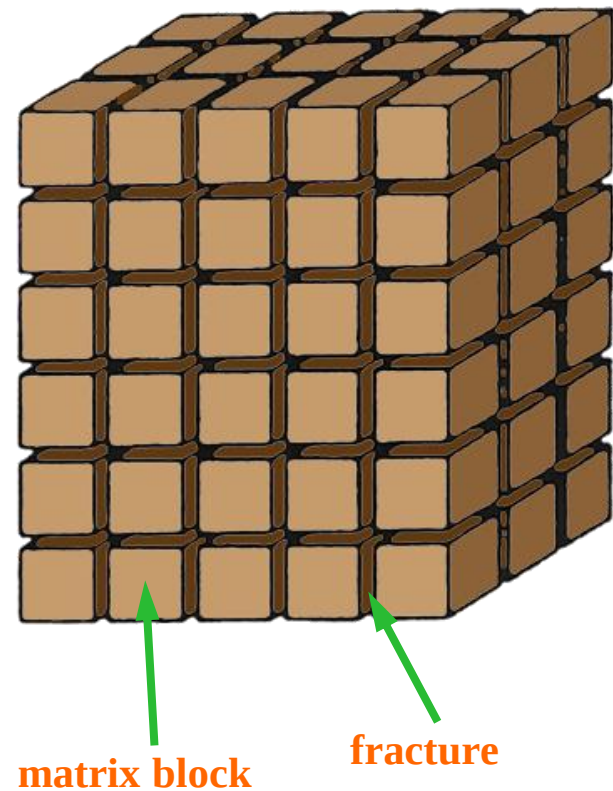


Fractured Reservoirs

ACTUAL RESERVOIR



MODEL RESERVOIR



Fractured Reservoirs

The four different dual porosity options are described below.

Only one type of dual porosity model can be specified in a data set.

- 1. DUALPOR (Dual Porosity)
- 2. DUALPERM (Dual Permeability)
- 3. MINC (Multiple Interacting Continue)
- 4. SUBDOMAIN



Fractured Reservoirs/ Dual Porosity

a) Standard Dual Porosity

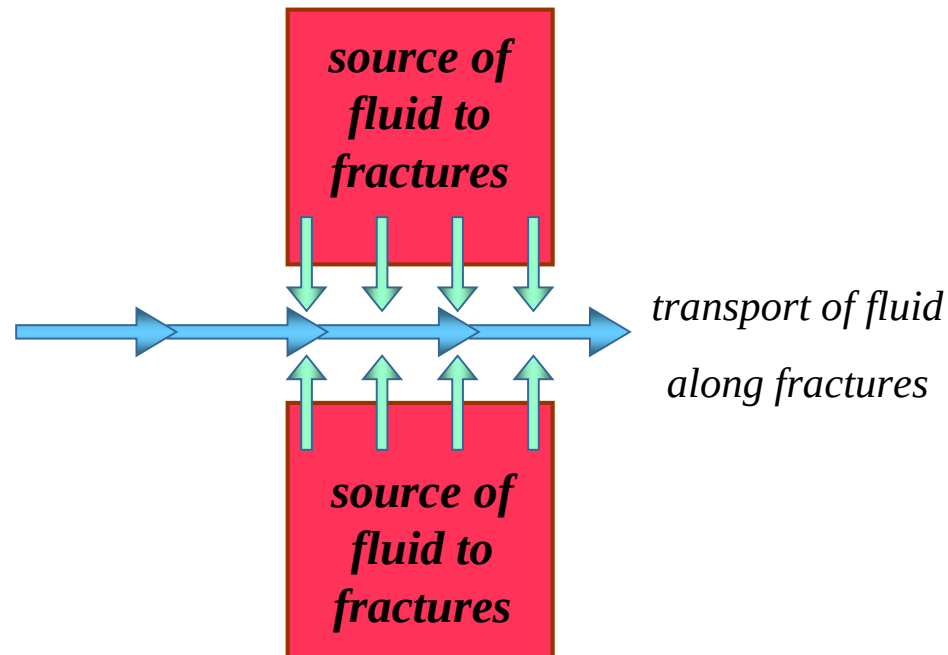
Fluid flow through the reservoir takes place through the fracture network. The matrix blocks essentially act as source and sink terms.

This model is invoked by specifying the keyword ***DUALPOR** in the Reservoir Description section.



Fractured Reservoirs/ Dual Porosity

In a conventional dual porosity model, the main transport of fluids takes place through the fractures, while the matrix blocks supply the fluids to the fractures. This is illustrated below:



Fractured Reservoirs/ Dual Permeability

b) Dual Permeability

This model differs from the standard dual porosity model in that each matrix block is connected to both the fracture blocks and the surrounding matrix blocks. Now, fluid flow occurs through both the fracture network as well as through the matrix blocks.

The dual permeability option can be important for cases where there is **capillary continuity**.

For these cases, dual permeability is often important for reservoirs with free gas, oil and large variations in depth.



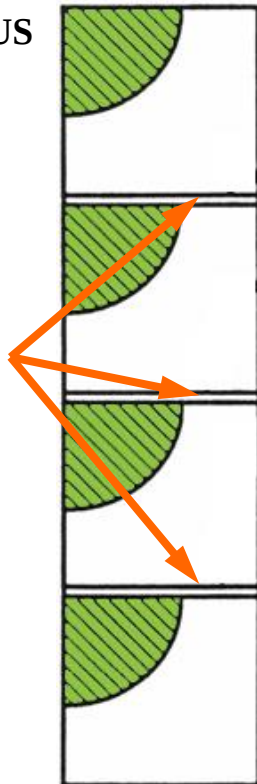
Fractured Reservoirs/ Dual Permeability

Usually, only the vertical k direction matrix-matrix transfer is important.

The dual permeability option is invoked by specifying ***DUALPERM** in the Reservoir Description section.

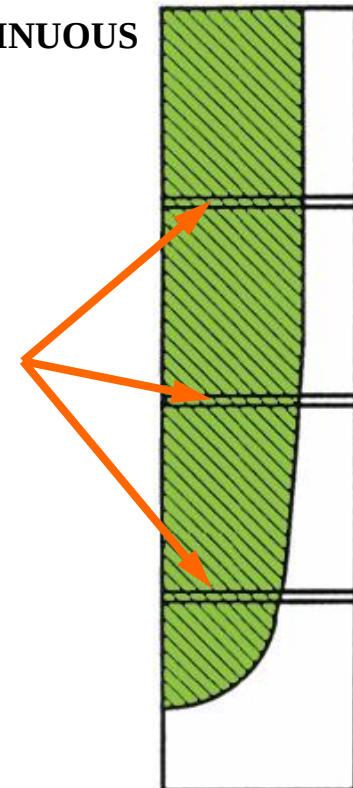
DISCONTINUOUS

*open fractures
with impermeable
matrix-to-matrix
contact or sealed
fractures*



CONTINUOUS

*fractures with
small fracture
widths ($<10\mu\text{m}$)
populated with
permeable
matrix contacts*



Fractured Reservoirs/ Subdomain

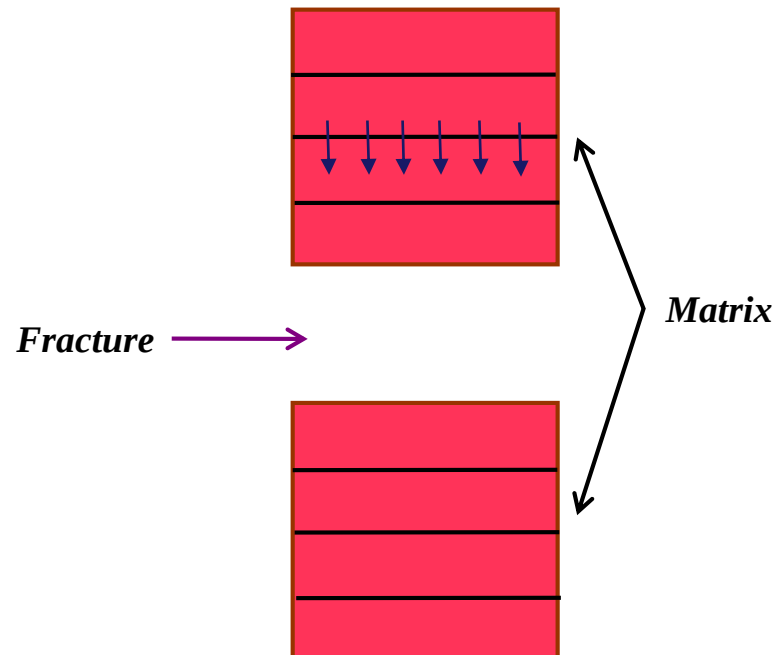
c) Subdomain

This model is a variation of the standard dual porosity option. It allows the user to refine the matrix blocks in the vertical direction in order to more accurately represent the **gravity drainage process** from matrix to fracture which is essentially vertical. Each matrix block is refined by the number of subdivisions specified in order to more accurately represent the **fluid pressures** and **saturations** within the matrix blocks. This resolution is not needed in the fracture, therefore only the matrix blocks are refined.



Fractured Reservoirs/ Subdomain

1. More accurately represent the gravity drainage process from matrix to fracture
2. More accurately represent the fluid pressures within the matrix blocks
3. More accurately represent the fluid saturations within the matrix blocks
4. This resolution is not needed in the fracture, therefore only the matrix blocks are refined.



Fractured Reservoirs/ Subdomain

The subdomain option is invoked by specifying ***SUBDOMAIN ndiv** in the
Reservoir Description section,

where ndiv is the number of refined layers for each matrix block.

Note that the value for **ndiv** is constant throughout the reservoir.



Fractured Reservoirs/ MINC

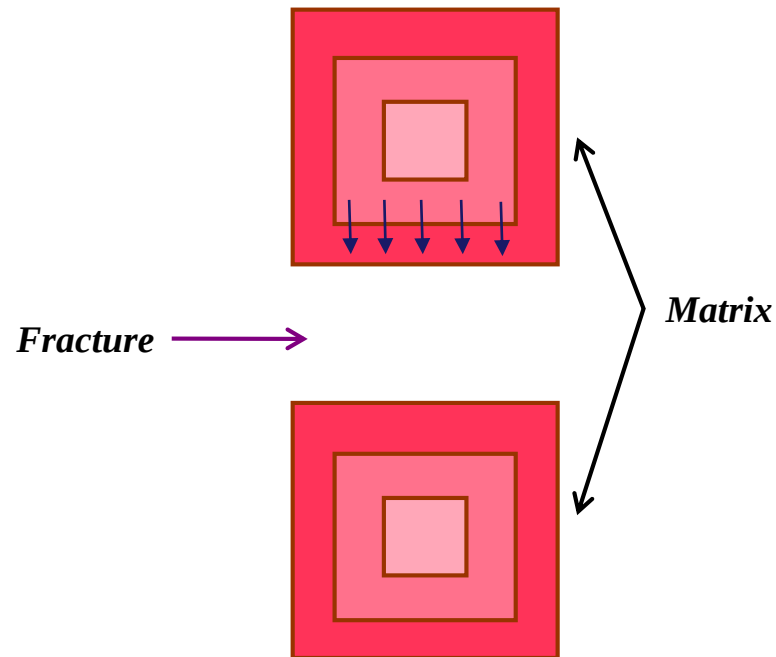
d) MINC

Another extension of the standard dual porosity concept is the multiple interacting continua (MINC) approach proposed by Pruess and Narasimhan. The main advantage of MINC is the representation of the matrix-fracture transfer calculation using a nested discretization of the matrix blocks. This allows a very efficient representation of the transient fluid regime, which is often neglected, in the standard dual porosity model.



Fractured Reservoirs/ MINC

1. Represent of the matrix-fracture transfer calculation using a nested discretization of the matrix blocks.
2. This allows a very efficient representation of the transient fluid regime.
3. The nested discretization is one-dimensional and can represent the pressure, viscous and capillary forces.
4. The gravity force however is not considered in this nested, one-dimensional matrix refinement.



Fractured Reservoirs/ MINC

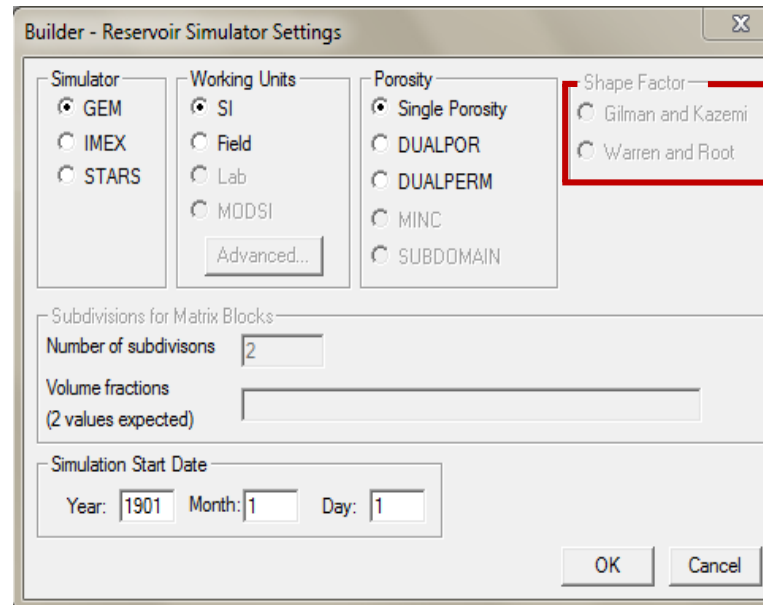
The nested discretization is one-dimensional and can represent the pressure, viscous and capillary forces. The gravity force however is not considered in this nested, one-dimensional matrix refinement.

The MINC option is invoked by specifying ***MINC ndiv** in the Reservoir Description section, where ndiv is the number of nested layers for each matrix block.

Note that the value for ndiv is constant throughout the reservoir.



Builder/ Shape Factor



1. Gilman and Kazemi (Permeability is variable in different directions.)
2. Warren and Root (The permeability is the same in different directions and the flow regime is pseudo steady state.)



Builder/ Subdivision for Matrix Blocks

Builder - Reservoir Simulator Settings

Simulator
☒ GEM
☐ IMEX
☐ STARS

Working Units
☒ SI
☐ Field
☐ Lab
☐ MODSI
[Advanced...](#)

Porosity
☒ Single Porosity
☐ DUALPOR
☐ DUALPERM
☐ MINC
☐ SUBDOMAIN

Shape Factor
☐ Gilman and Kazemi
☐ Warren and Root

Subdivisions for Matrix Blocks

Number of subdivisions

Volume fractions
(2 values expected)

Simulation Start Date
Year: Month: Day:

OK Cancel



Builder/ Simulation Start Date

Builder - Reservoir Simulator Settings

Simulator
☒ GEM
☐ IMEX
☐ STARS

Working Units
☒ SI
☐ Field
☐ Lab
☐ MODSI
[Advanced...](#)

Porosity
☒ Single Porosity
☐ DUALPOR
☐ DUALPERM
☐ MINC
☐ SUBDOMAIN

Shape Factor
☐ Gilman and Kazemi
☐ Warren and Root

Subdivisions for Matrix Blocks
Number of subdivisions
Volume fractions
(2 values expected)

Simulation Start Date
Year: Month: Day:

OK Cancel



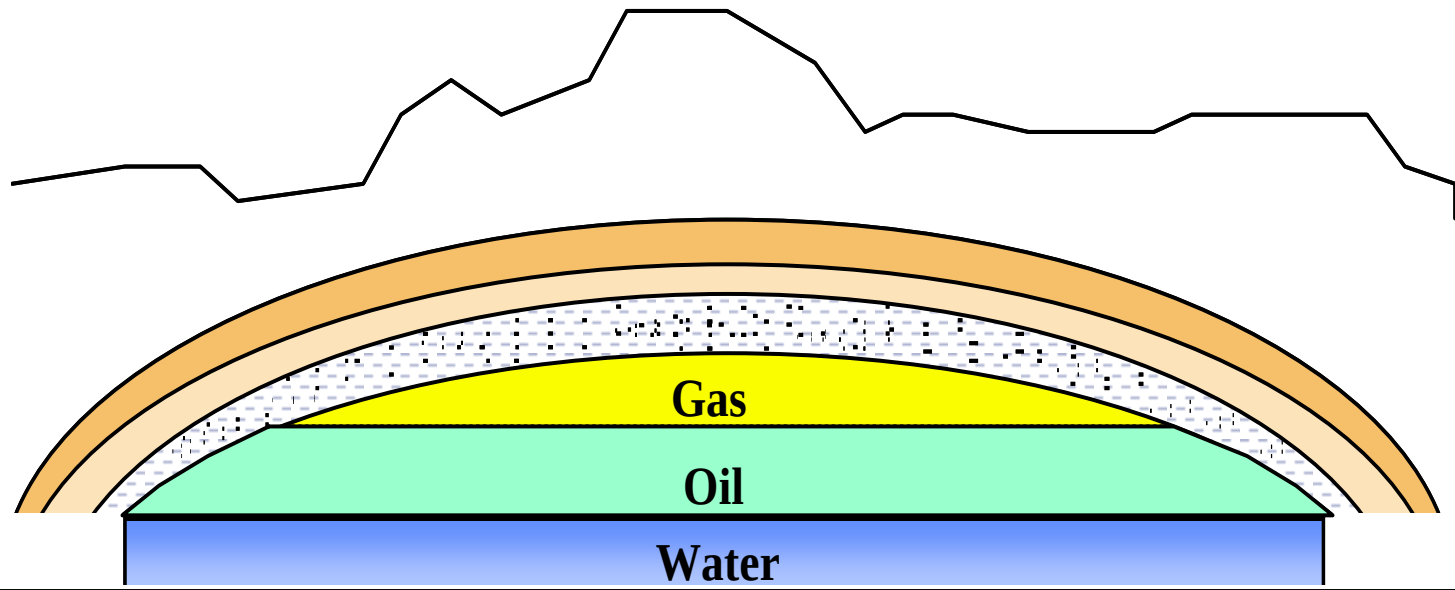
Opening BUILDER 2006.10

Opening BUILDER 2006.10

1. Open Builder 2006.10 by double clicking on the appropriate icon in the Launcher.
2. Choose:
 - ♦ IMEX Simulator, SI Units, Single Porosity
 - ♦ Starting date 1991-01-01
3. Click OK twice.



Creating the Simulation Grid (structural data)

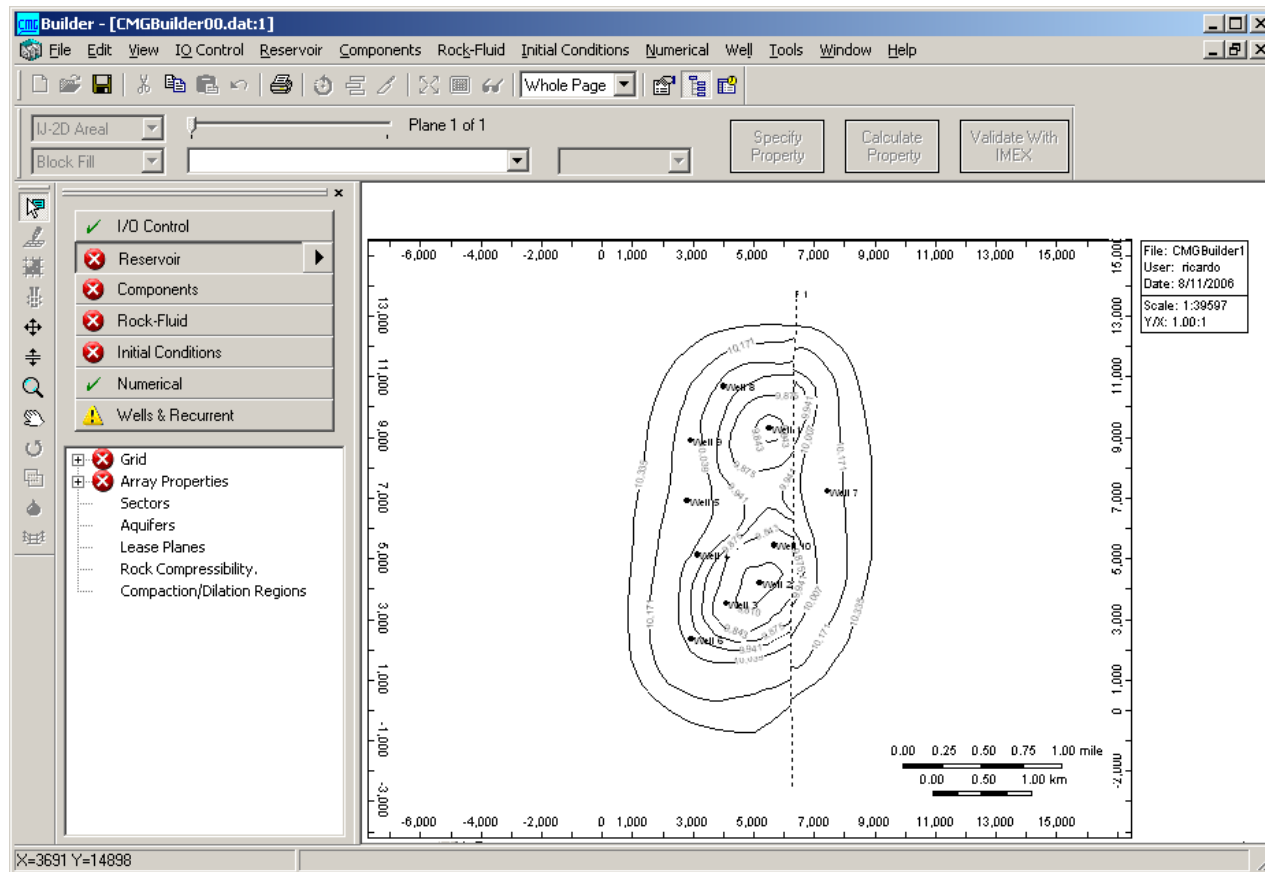


Creating the Simulation Grid (structural data)

1. Click on File (on the menu bar, top left), then “Open Map File...”.
2. Choose “Map Type – Atlas Boundary format (.bna)” and m in “Units for X,Y coordinates in the files” box.
3. Select the Top-of-Structure map file called “Top.bna” by clicking on the Browse button and locating the file.
4. Click OK.



Creating the Simulation Grid (structural data)



Creating the Simulation Grid (structural data) / Isopachous Maps

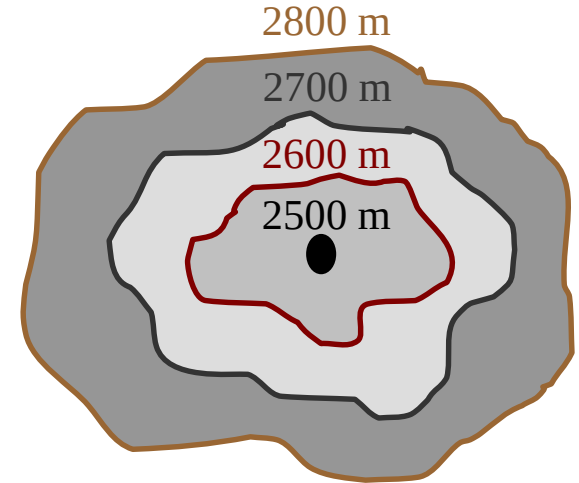
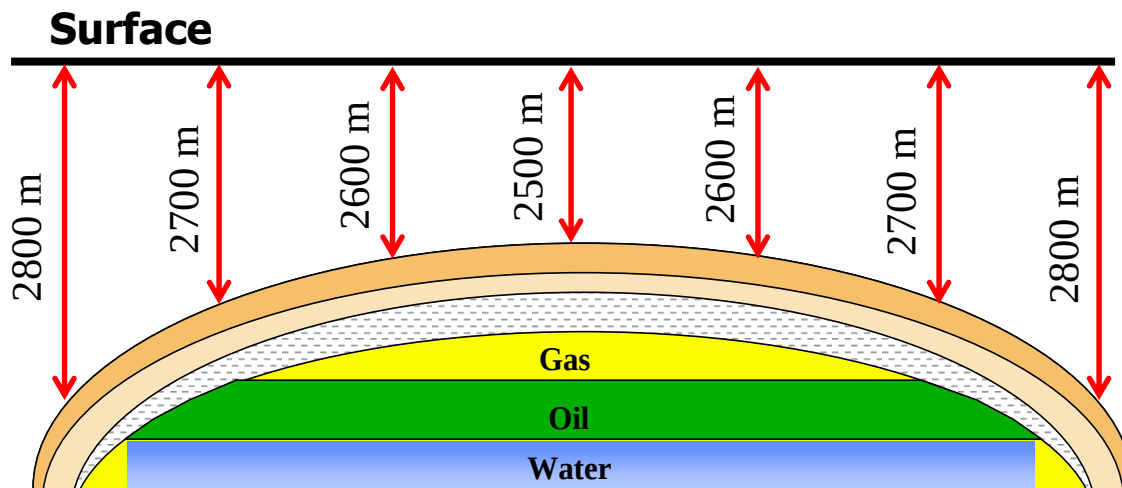
What is **isopachous Maps** Application?



Creating the Simulation Grid (structural data) / Isopachous Maps

Isopachous Maps

are drawn based on the same thickness points (depth) in a formation.



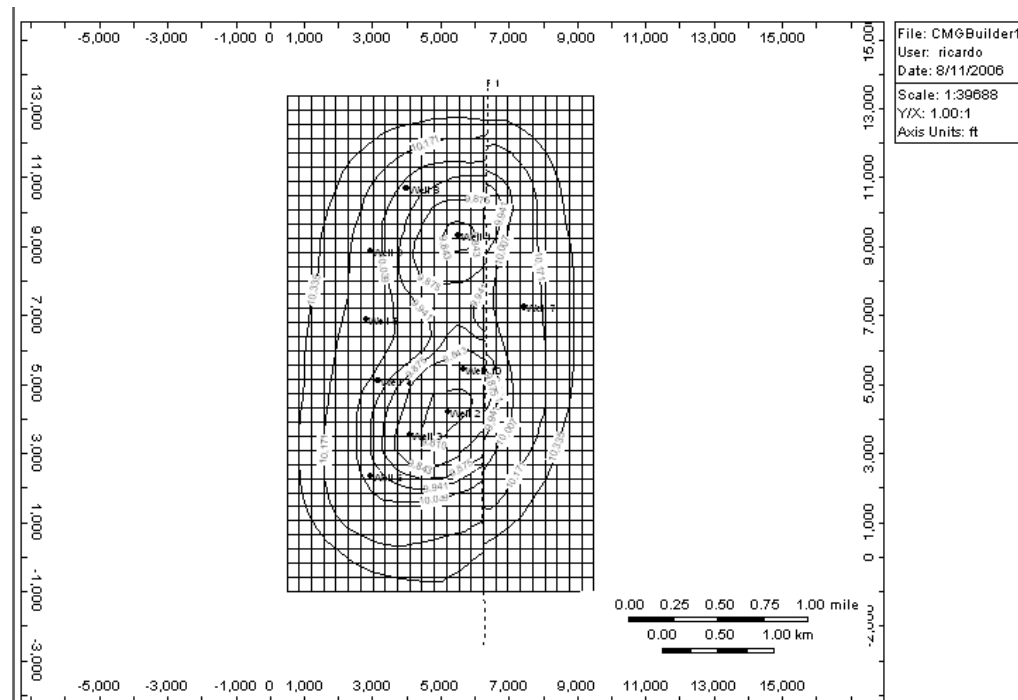
Creating the Simulation Grid (structural data)

5. Maximize the screens for a better view by clicking on the window maximize button.
6. Click “Reservoir” (on the menu bar) and “Create Grid”.
7. Select **Orthogonal Corner Point** and specify a **25** (I-direction) x **35** (J-direction) x **4** (K-direction) grid.
8. Enter **25*110** in the I direction box (meaning all **25** columns in the I-direction will be **110** meter in) length.
9. Enter **35*125** in the J-direction box (meaning all **35** rows in the J-direction will be **125** meter in length).
10. Click **OK**.



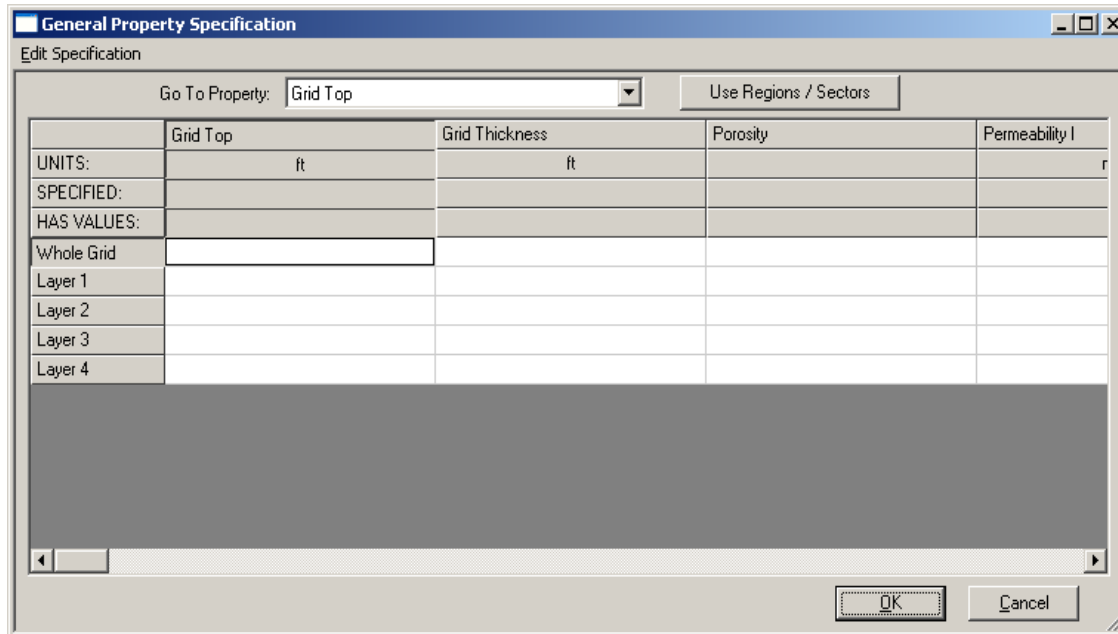
Creating the Simulation Grid (structural data)

11. Hold down **Shift key** and hold down **left mouse button** to **move (pan) grid**.
12. Hold down **Ctrl key** and hold down **left mouse button** to **rotate grid**.
13. Align the grid with the fault so that a grid block boundary lies along it, and the grid covers the whole map area.



Creating the Simulation Grid (structural data)

14. Change display control to Probe mode by clicking on this  toolbar button on left hand side.
15. Click on the **Specify Property** button (top middle of screen) to open the **General Property Specification** spreadsheet as shown below.



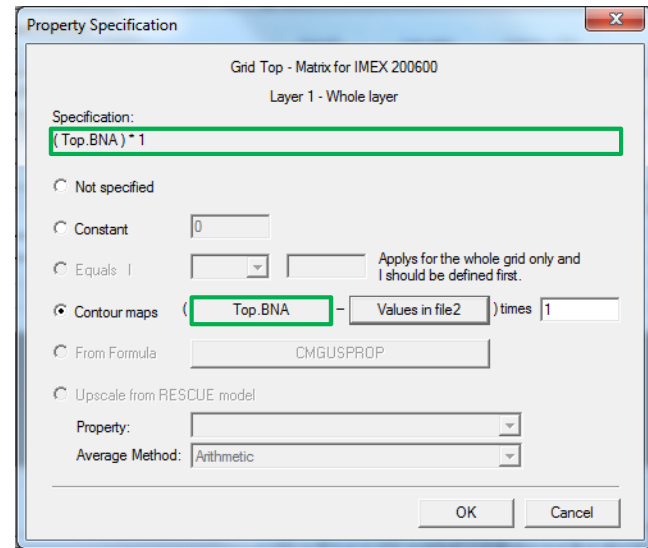
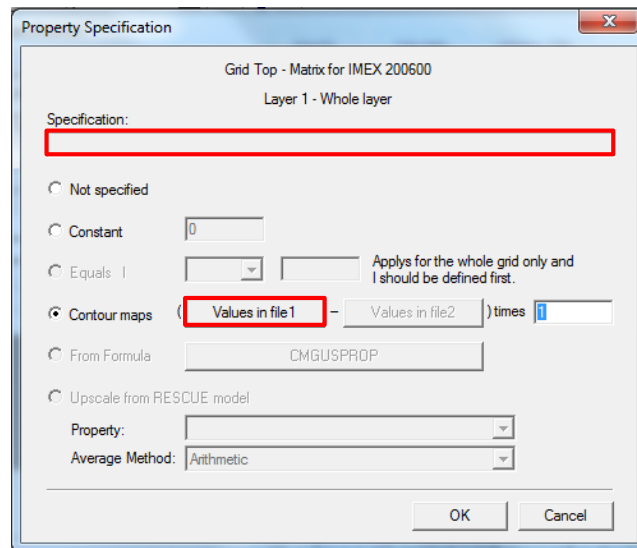
The image shows a software window titled "General Property Specification" with a subtitle "Edit Specification". It features a "Go To Property:" dropdown menu set to "Grid Top" and a "Use Regions / Sectors" button. Below this is a table with five columns: "Grid Top", "Grid Thickness", "Porosity", and "Permeability I". The table has rows for "UNITS:", "SPECIFIED:", "HAS VALUES:", "Whole Grid", "Layer 1", "Layer 2", "Layer 3", and "Layer 4". The "UNITS:" row shows "ft" for "Grid Top" and "Grid Thickness", and "r" for "Permeability I". The "Whole Grid" and "Layer" rows are currently empty. At the bottom of the window are "OK" and "Cancel" buttons.

	Grid Top	Grid Thickness	Porosity	Permeability I
UNITS:	ft	ft		r
SPECIFIED:				
HAS VALUES:				
Whole Grid				
Layer 1				
Layer 2				
Layer 3				
Layer 4				



Creating the Simulation Grid (structural data)

16. Select the box for **layer 1** under the property column labeled **Grid Top**. **Right click** in this box and select the **Geological Map** option as the data source.
17. Click the **Values in file1** button, then Browse and select the top-of-structure map file called **Top.bna** (it should already be selected from previous actions).
18. Click **OK** to return to the spreadsheet type window.



Creating the Simulation Grid (structural data)

19. Repeat this action for **Grid Thickness in the layer1 box**, but this time select **Thickness.bna** in the Values in file1 box. Also, enter **0.25** in the times box (still on the property specification menu) in order to allocate 25% of the total thickness map to each of the 4 layers in the grid. Finally, **copy** the layer1, Grid Thickness cell contents and **paste** it into the layer 2, layer 3 and layer 4 Grid Thickness cells to complete the specification of Grid Thickness source data for each of the 4 layers in the grid.

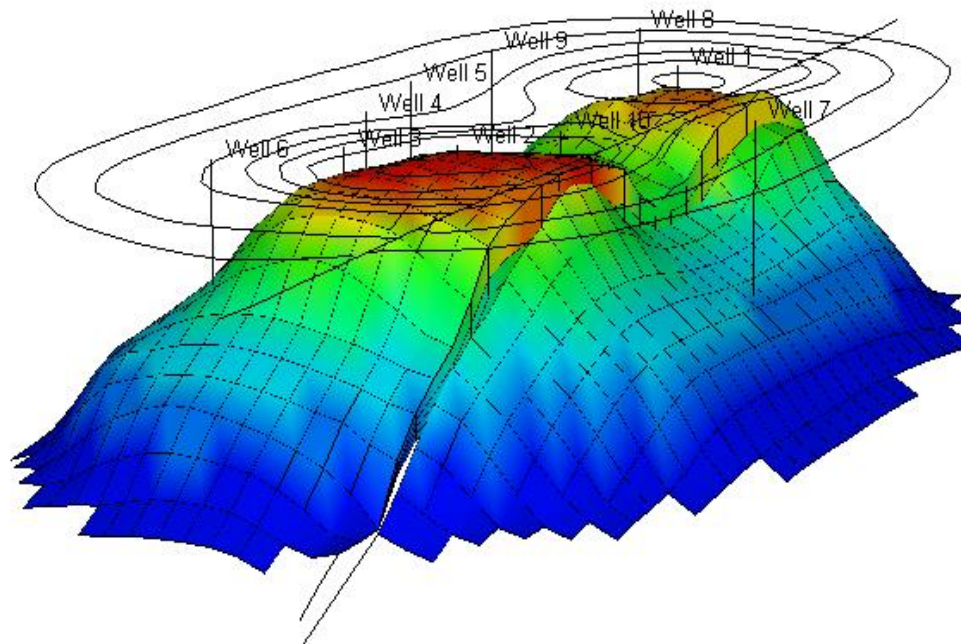
20. Click **OK** the Calculate **Property button** will pop up click OK to populate the grid with top-of-structure and grid thickness data (this operation is performed by BUILDER using the specified map data to interpolate grid cell values). Press OK to the message that appears regarding values being clamped.

21. Change the view from **IJ-2D Areal to 3D View** (in the upper left corner!!).



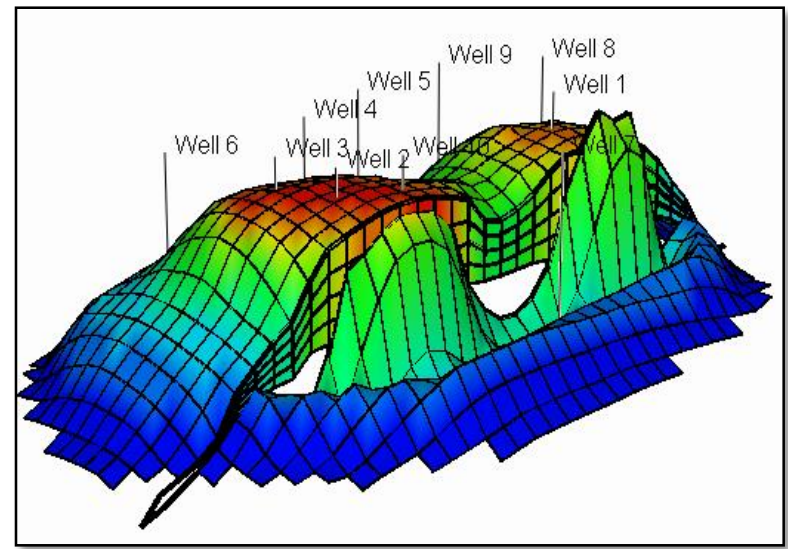
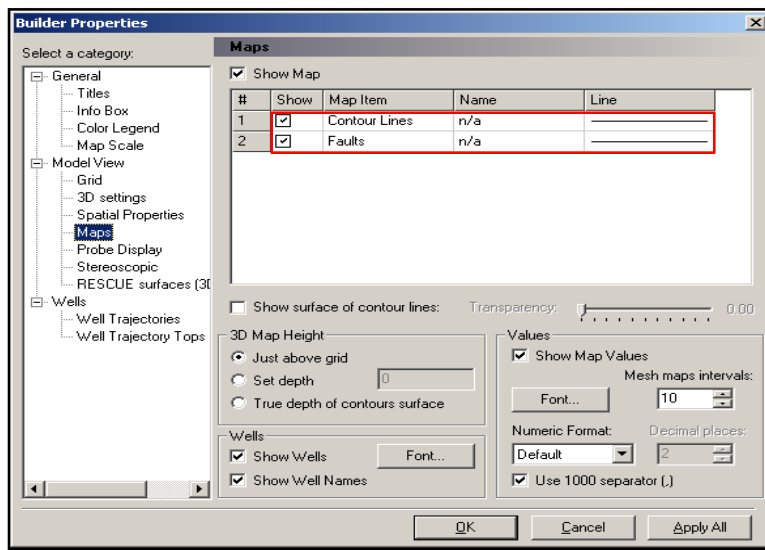
Creating the Simulation Grid (structural data)

22. Click on the **Rotate (3D View) button**  (from the toolbar) to rotate the display by holding down the left mouse button and using the cursor to move the model. Hold down the **Ctrl key** with the left mouse button and move the mouse toward the bottom of the screen **to zoom in** or move the mouse to the top of the screen **to zoom out**.



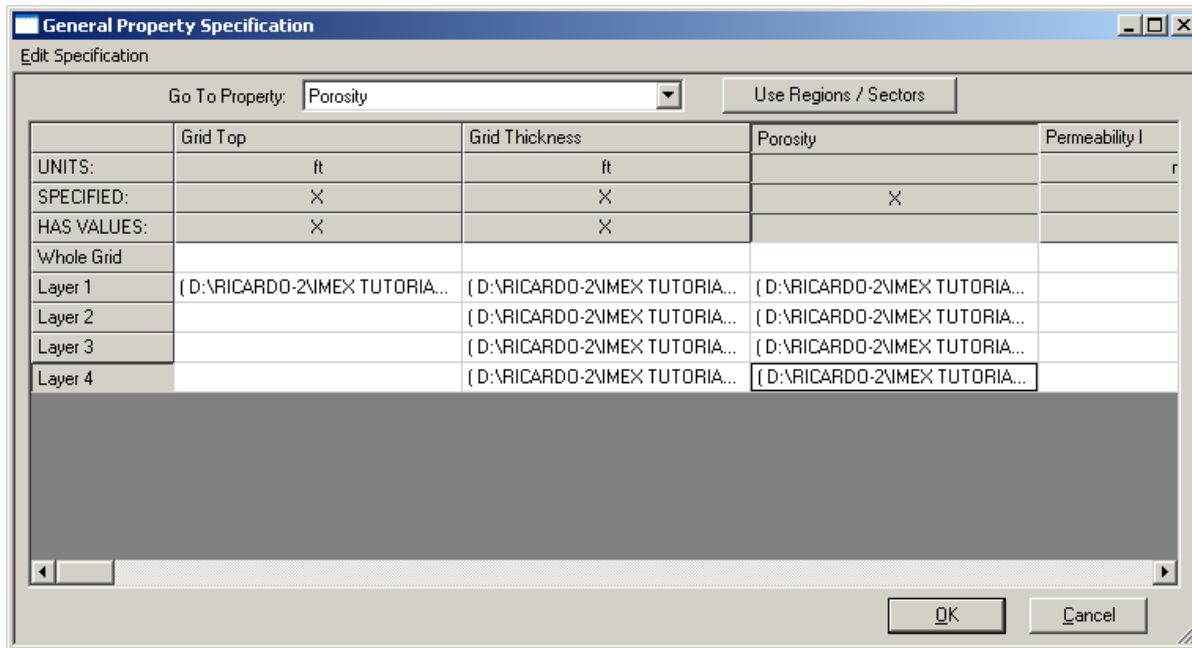
Creating the Simulation Grid (structural data)

23. To remove the contour map from the display, **click the right mouse button** while the cursor is anywhere in the display area. Select **Properties** from the displayed menu (bottom of list), **Maps** from the tree view; and (finally) uncheck the **Show Map Contours Lines** and **Fault** boxes. Press **OK**.



Assigning Porosity & Permeability to the Model

24. Repeat the above process for **Porosity** (i.e. similar to step #19), but select the map **Porosity.bna**. Use the same map for each layer. This time, leave the value in the **times** box set to **1** in order to allocate the whole porosity map to each of the 4 layers in the grid.



	Grid Top	Grid Thickness	Porosity	Permeability I
UNITS:	ft	ft		
SPECIFIED:	X	X	X	
HAS VALUES:	X	X		
Whole Grid				
Layer 1	{ D:\RICARDO-2\IMEX TUTORIA...	{ D:\RICARDO-2\IMEX TUTORIA...	{ D:\RICARDO-2\IMEX TUTORIA...	
Layer 2		{ D:\RICARDO-2\IMEX TUTORIA...	{ D:\RICARDO-2\IMEX TUTORIA...	
Layer 3		{ D:\RICARDO-2\IMEX TUTORIA...	{ D:\RICARDO-2\IMEX TUTORIA...	
Layer 4		{ D:\RICARDO-2\IMEX TUTORIA...	{ D:\RICARDO-2\IMEX TUTORIA...	



Assigning Porosity & Permeability to the Model

25. Select **Permeability I** from the list on the panel and enter the following:

Layer 1	50
Layer 2	250
Layer 3	500
Layer 4	100

26. Select **Permeability J** and right click in the **Whole Grid** box. Select **EQUALSI** then **OK**.

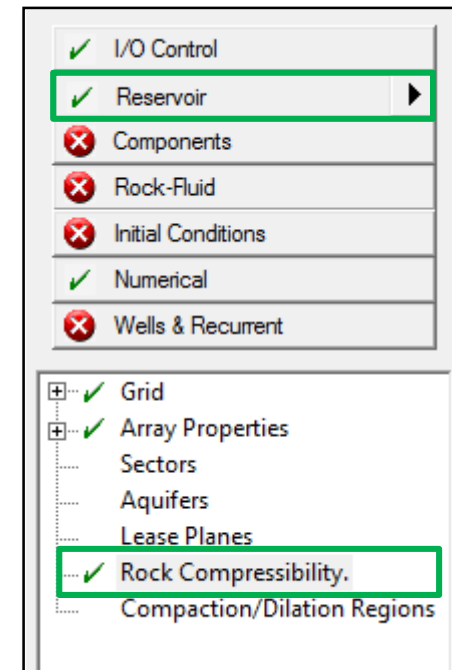
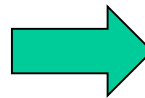
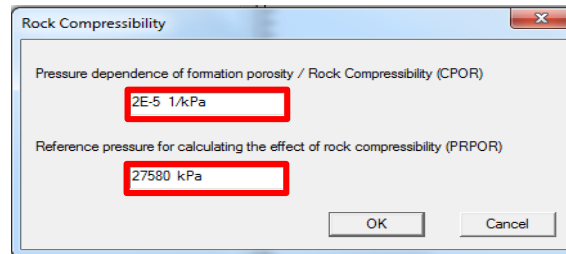
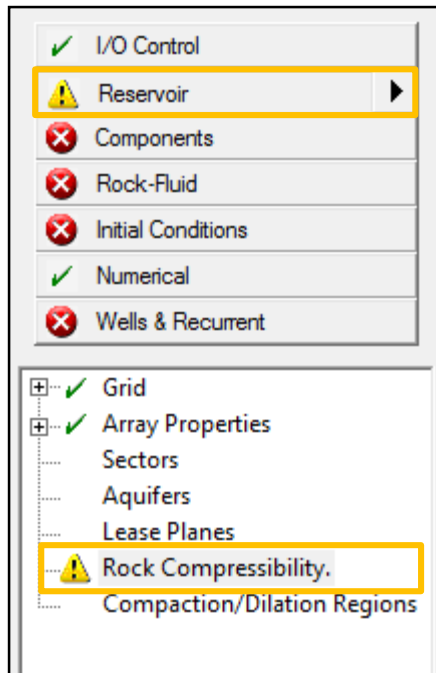
27. Do the same with **Permeability K** and select **EQUALSI**. In the first box select ***** and then enter a value of **0.1** in the second field (**this applies a K_v/K_h ratio of 0.1**). Press the **OK** button.

28. Press **OK** to leave the General Property Specification section and then press **OK** to calculate the Properties.



Assigning Porosity & Permeability to the Model

29. Double click on **Rock Compressibility** in the tree view menu and input **2E-5 1/kPa** in the **rock compressibility box**, **27580 kPa** in the **reference pressure box** and **OK**. Units will be applied automatically; you should now have the **Green** check mark for Reservoir section.



Assigning Porosity & Permeability to the Model



30. This would be a good point to save the data set you are working on. Click **File** then **Save As**. Save file as **Tutorial.dat**.

