Saphir Guided Session # 3

A01 • Introduction

It is assumed that you have already studied the guided sessions # 1 and # 2. The following session describes the numerical model. It uses the file SapGS03_FieldMap.bmp, SapGS03_Porosity.txt and SapGS03_Thickness.txt. This session is divided into three sections:

B: Building the numerical model.
C: Using the numerical model.
D: Using the numerical model with other features and graphics.

Launch Saphir and create a new project with default settings.

B01 • 2D Map

Click on the tab “2D Map”. The “Tested well” has been defined in the middle of the default rectangle and the coordinates of the well is at (0,0).

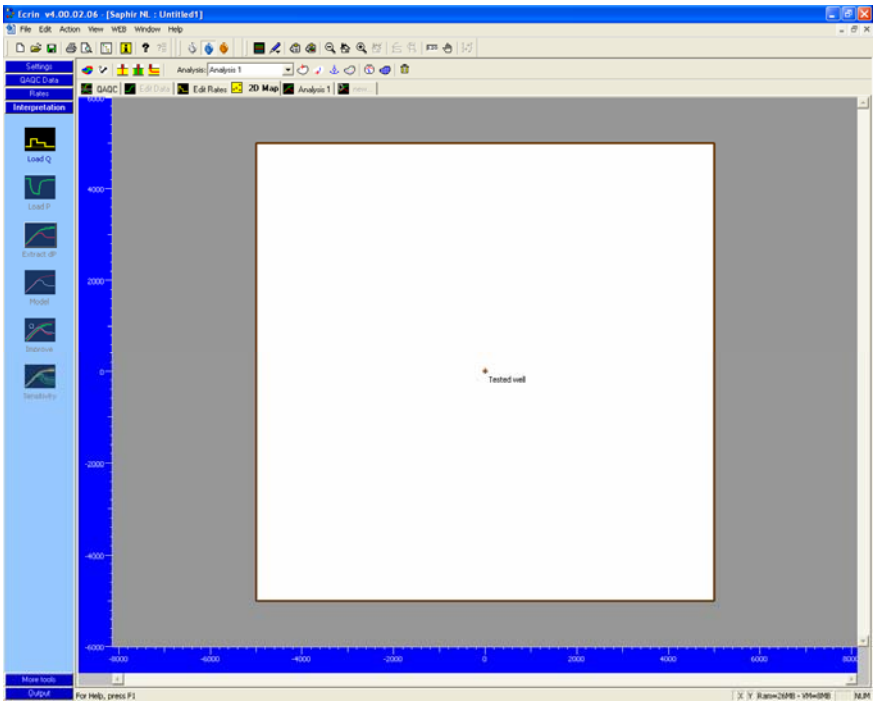


Fig B01.1

Double click on the tested well and the well radius can be set and the coordinates can be confirmed at (0,0). The well can be a limited entry type or radial composite. The geometry of the well can be vertical, horizontal or fractured set in the geometry droplist. You enter or load the production of the well under the tab “Production”. The rate history of the tested well can also be loaded through the interpretation page.
As the objective of this section is to illustrate the use of the 2D Map only we will not load a production history.

In the 2D Map toolbar click on  to load the bitmap file SapGS03_FieldMap.bmp. This and all the other 2D Map options are also accessible, and mirrors the toolbar, through the popup menu available with a right click in the 2D Map area.

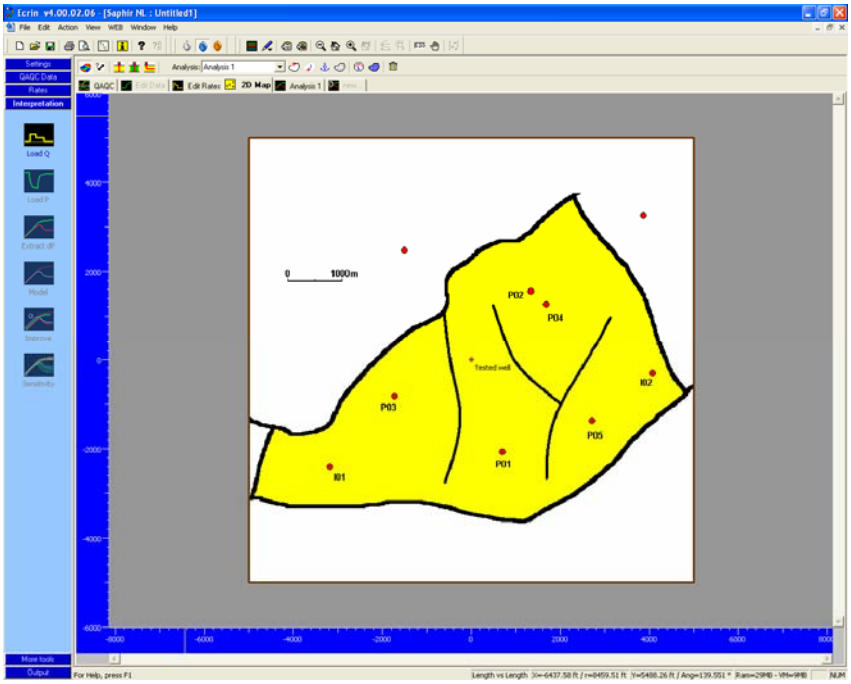


Fig B01.2 Load bitmap

The tested well can be moved to PO1 using the mouse. The use of the bitmap is to help you in defining contours, other wells, faults and setting the scale.

Define the other vertical wells using the  icon. Fractured  and horizontal  wells can also be defined using the toolbar or the popup menu. Define P03 as a fractured well, click once to set one end of the fracture and click a second time to terminate. The position of the well can be changed interactively afterwards using the mouse. By clicking on the well the fracture length and orientation can again be changed using the mouse. Double clicking on the well allows the specification of exact fracture half length. Double click on each of the wells to change the name in the well dialog to the appropriate well name indicated on the bitmap. In the well dialog the properties of the wells can be changed and the production histories loaded or entered. The sense of the tested well (the well with a “physical” pressure gauge) can be changed to other wells and any wells can be excluded from any consequent model generation or simulation.

The next step is to draw the contour of the field. Click on  and start by a first click anywhere on the contour indicated by the bitmap, move the mouse to a next point on the contour, click again.

Proceed around the contour by moving the mouse and clicking until the “rubber band” of the overlaid trace is complete. Double click to finish. Any time a mistake is made you can go back by using the Esc. key. A double click on the contour will bring up the contour dialog where you can reset the contour to a circle or rectangle and browse the size of the current contour area. The trajectory can be loaded from an outside file or modified manually. Segments of the contour can be set to constant pressure or sealing.

There is a scale indicator on the map and we need to set the scale. Click on the icon and use the mouse to draw a line from 0 to 1000 m on the scale indicator. To be more accurate it is a good idea to zoom on the scale indicator before this operation. Set 1000 m in the Length box of the dialog.

Finally we will draw in the sealing faults indicated on the bitmap. Click on and use exactly the same technique used to draw the contour. When a node on the contour or on an existing fault turns green it means that the fault you are in the process of drawing will snap to this point. Double clicking on a fault will bring up the fault dialog where the fault can be set to sealing or any degree of leakage. The trajectory can also be browsed or modified.
The bitmap is only a visualization of the field and has helped you to set up the model, it is no longer needed and it can be hidden. Click on the icon again to hide it. Your 2D Map should look like Fig B01.3.

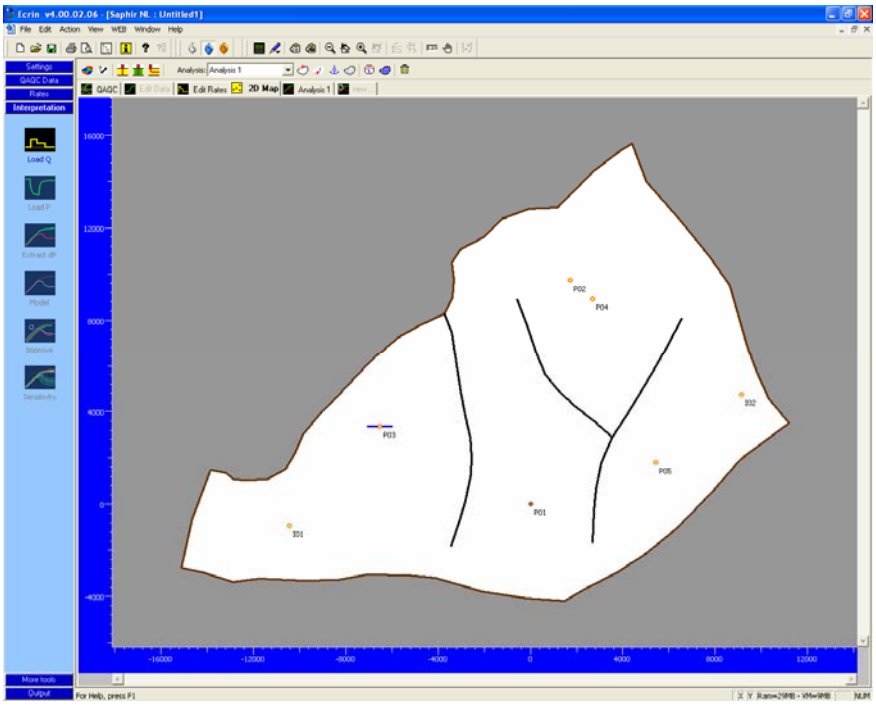


Fig B01.3 Finalized model

Clicking on the  icon will calculate the automatic Voronoi grid with local refinements around each well.

Clicking on the settings  icon will access amongst others the tab 

for manual grid control. The Voronoi grid is the basis for the numerical solution of the pressure at the tested well and solves for the influence of the tested well and the influence from any wells added during the simulation. However the field map can also be used for analytical multi well simulations. Fig B01.4. (Only the well position is retained in this case).

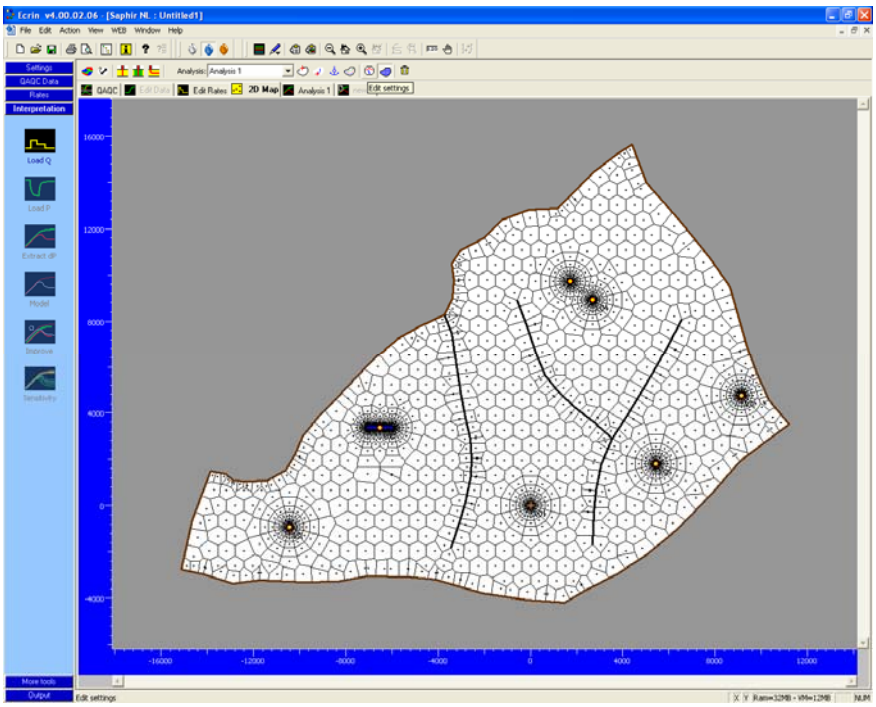


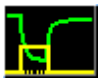
Fig B01.4 Voronoi grid

C01 • Using the numerical model

C01.1 • Comparing numerical and analytical model

Lets use the model set up in the previous section and declarer a flowrate for the tested well P01. This can be done by double clicking on the well or loading the data from the interpretation panel as covered in the previous section.

Enter manually 1000 hrs of 1000 STB/D.

Choose the More tools panel and the  icon, Test Design. Select the tab Numerical, the numerical model. Accept the default model parameters and check the options “store pressure fields” and “display during generation”. Fig C01.1.

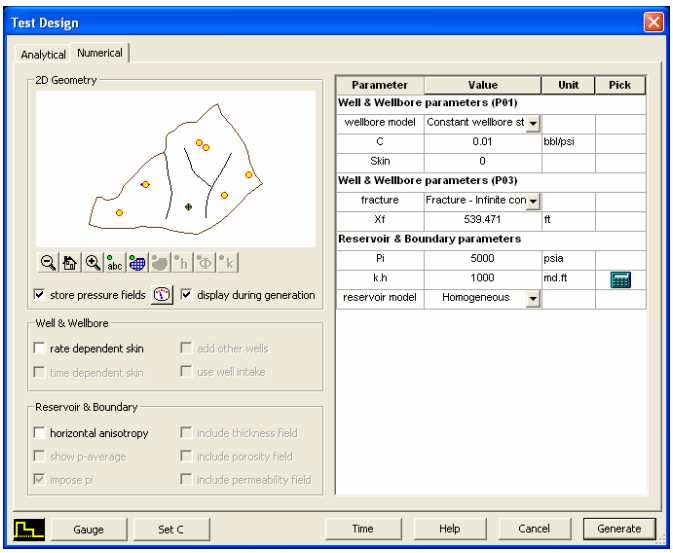
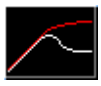


Fig C01.1 Model dialog

Generate the model and extract normally the pressure response. The simulated pressure in the tested well is displayed in the loglog plot in Fig C01.2 left and exhibits clearly the near parallel faults of our model. It can also be seen from the pressure fields, Fig C01.2 right, that the initial pressure is still maintained in the outer parts of the reservoir thus the effect seen is not pseudo steady state. During the generation you can observe the pressure field animation in the geometry plot.

The distance to the faults from P01 is approximately 2700 and 2800 ft respectively. Click on model  and choose the analytical tab, define the boundary model as parallel faults. Input the distance to the faults equal to those of the 2D Map and generate. The match is near perfect and illustrated in Fig C01.3.

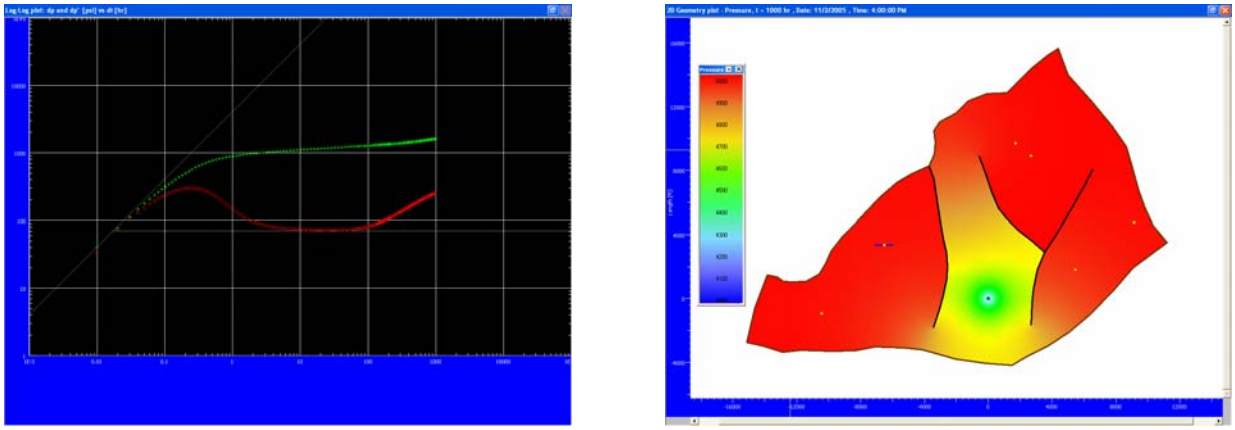


Fig C01.2 Loglog plot and pressure fields

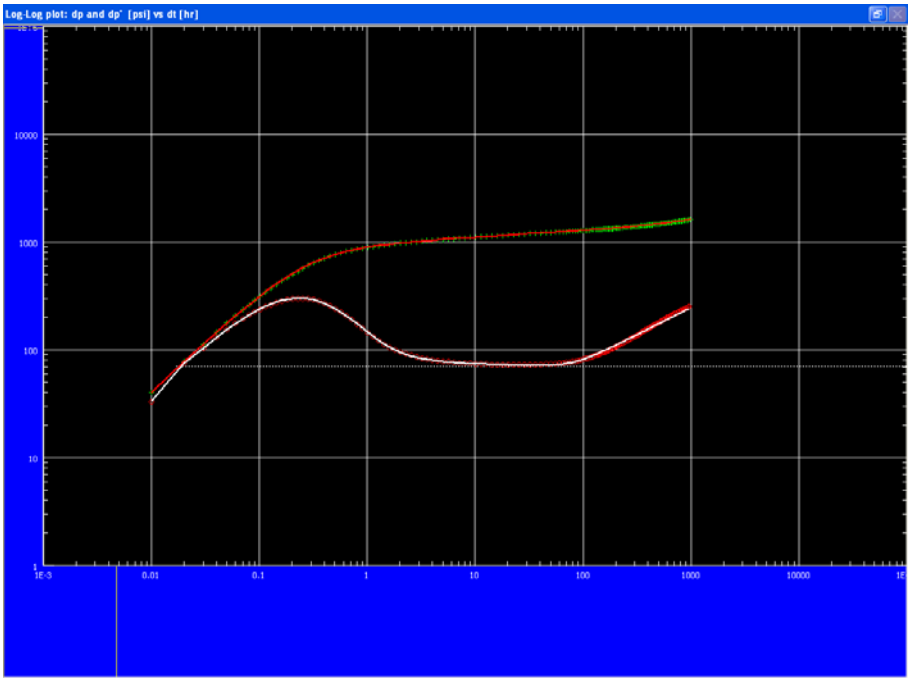


Fig C01.3 Model match with analytical model

The generation of the analytical model will remove the 2D geometry plot. Go back to the model dialog and regenerate the numerical model with the default parameters as before with the option “store pressure fields”.

C01.2 • Geometry plot

As we chose to store and display the pressure fields during the generation of the numerical model we can now study the evolution of the fields in greater detail. Maximize the geometry plot.

In the plot toolbar we have some “tape recorder” type icons. These are used to browse from a pressure field captured at a preset rate and time to another and can be used to play back the whole sequence. Click on the  icon to move to the first recorded field at production startup. Then click on  to play back all the stored fields.

It is also possible to move from field to field in time by the use of the back  and forward  icons. You can also choose exactly which field you want to display in the settings dialog accessed from the  icon. The settings dialog also allows you to define the items you want to display on the geometry plot, which type of field to display in case more than the pressure field has been generated by the simulation. You are also able to define the color scale. Click on this icon and choose the tab , choose “View field at” 500 hours.

Click on the  icon to display the 500 hours field in pseudo 3D view, you may have to use the zoom options in order to get a similar screen as the one shown in Fig C01.4. It is quite remarkable how this view confirms that mostly the channel is being drained after 500 hours production.

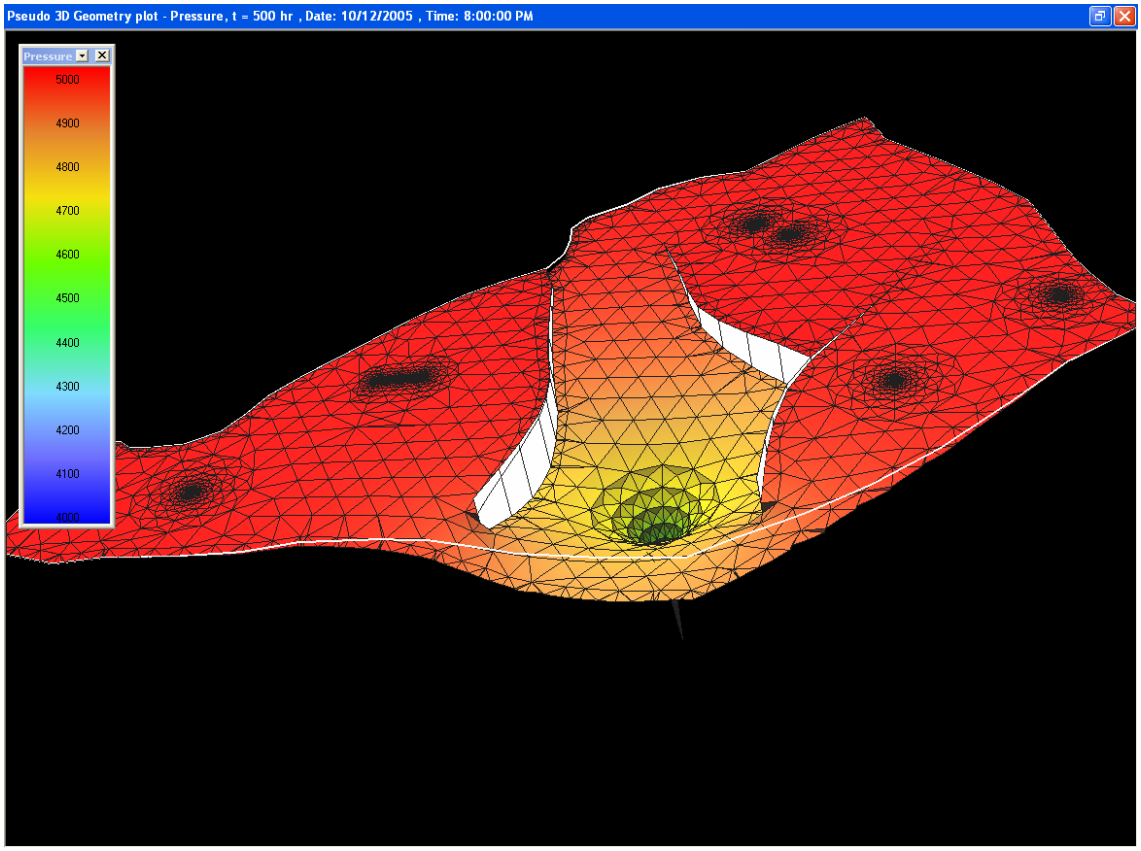
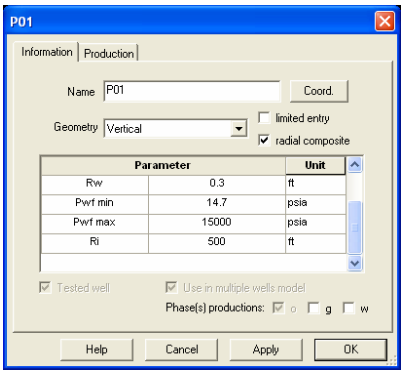


Fig C01.4 Pseudo 3D view

D01 • Using the numerical model with other features and graphics

D01.1 • Radial composite well

Maximize the geometry plot which is still in pseudo 3D mode and click on  icon in the toolbar to return to the 2D mode display. Activate the 2D Map  and double click on the tested well P01. In the dialog check the radial composite well and declare in the dialog a distance to the radial composite interface of 500 ft.



Now drop a composite anchor,  icon in the toolbar, in the zone beyond the radial composite circle displayed in the 2D Map. The anchor allows the specification of a different mobility and diffusivity in the outer zone. Double click on the anchor and change the name to outer zone.

Call the model dialog and specify M and D at 0.1 indicating an increase in mobility in the outer zone. The color of the outer zone in the 2D Map is carried over to the model dialog to easily identify the zoning when multiple zones are used. Generate the numerical model. Fig D01.5 left; model dialog and Fig D01.5 right, the model response in the loglog plot.

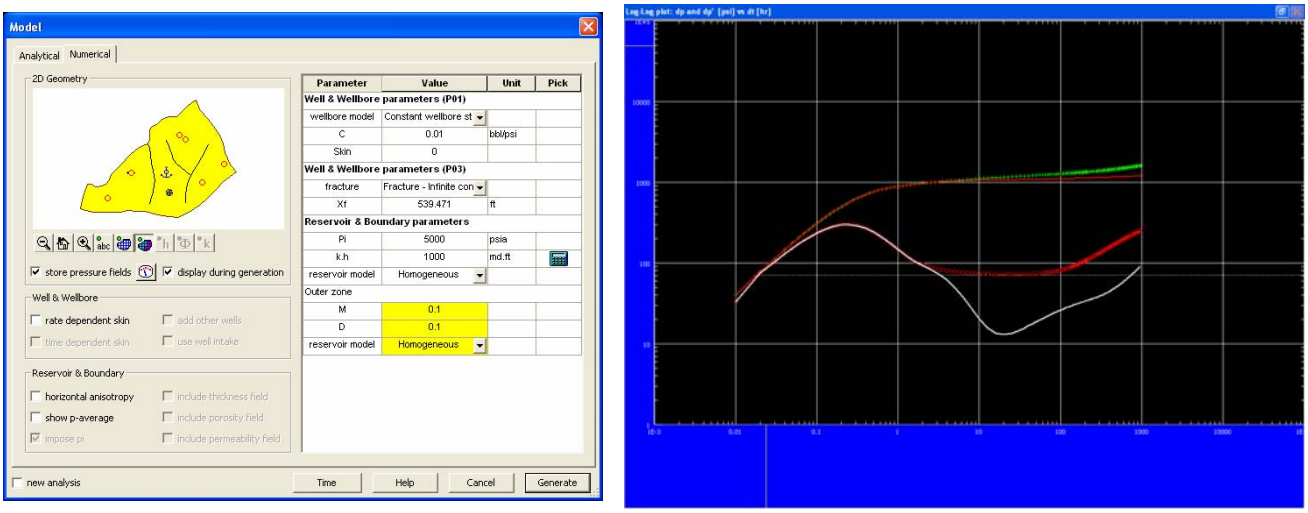


Fig D01.1 Model dialog and generated response

The difference between the homogeneous and the composite numerical model can be observed.
In the 2D Map, the “white” zone corresponds to the pressure and time matches and is the reference. The M and D ratios are then: (white zone)/(colored zone). Setting the Composite anchor outside the circle surrounding the well defines the composite system with the same convention as the analytical model, the M and D ratio are: (inner condition)/(outer condition).

D01.2 • Composite reservoir

Select the 2D Map tab again, and choose to draw two new faults cutting the reservoir in three zones as illustrated in Fig D01.2 left. The new zones are colored white indicating that the mobility and diffusivity have not been set and are equal to the mobility and the diffusivity of the radial composite well. Drop a composite anchor in each of the new zones. This will change the color of the zones and enable the setting of M and D in the numerical model for regeneration of the model response. Fig D01.2 right. In order for these reservoir zones to be taken into account in the model the faults separating them from the central reservoir have to be fully or partially leaky. Double click on each of the fault and change the leakage factor.

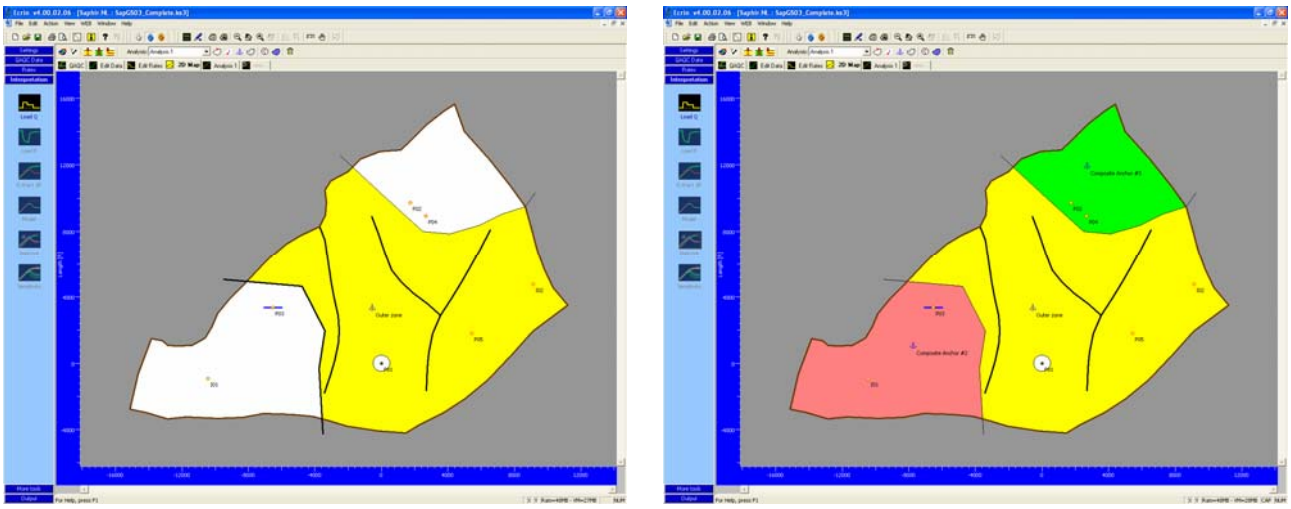


Fig D01.2 Composite reservoir

D01.3 • Constant pressure boundary

To set a segment of the contour to constant pressure, double click on the contour and select the tab Sealing vs Ct pressure. From here you can easily select the segments to be set to constant pressure or sealing.

D01.4 • Data fields

We will simplify our 2D Map to demonstrate some other features of setting up the basis for the numerical model. Select the 2D Map and delete the composite anchors, the leaky faults and the radial composite option of well P01. Use the icon and hover over the item you want delete and click.

Click the icon in the toolbar to load a data field. It is possible to load field wide thickness, porosity and permeability to be taken into account during the simulation.

In this case we will proceed to load field wide thickness and porosity. The files to use are stored in the Example directory; SapGS03_Thickness.txt and SapGS03_Porosity.txt. Proceed to load the files in the 2D data edition dialog, one by one specifying the value you load in the droplist in this dialog. Click on the settings icon; in the Display... tab you can choose which value to display in the 2D Map. The coloring is governed by the choice of interpolation scheme. The default interpolation can be changed in the tab Data Interpolation in the same dialog. Fig D01.3 illustrates the 2D Map with default interpolation and the porosity map on the left and thickness on the right. The black points are displayed at the coordinates and the numerical values are shown.

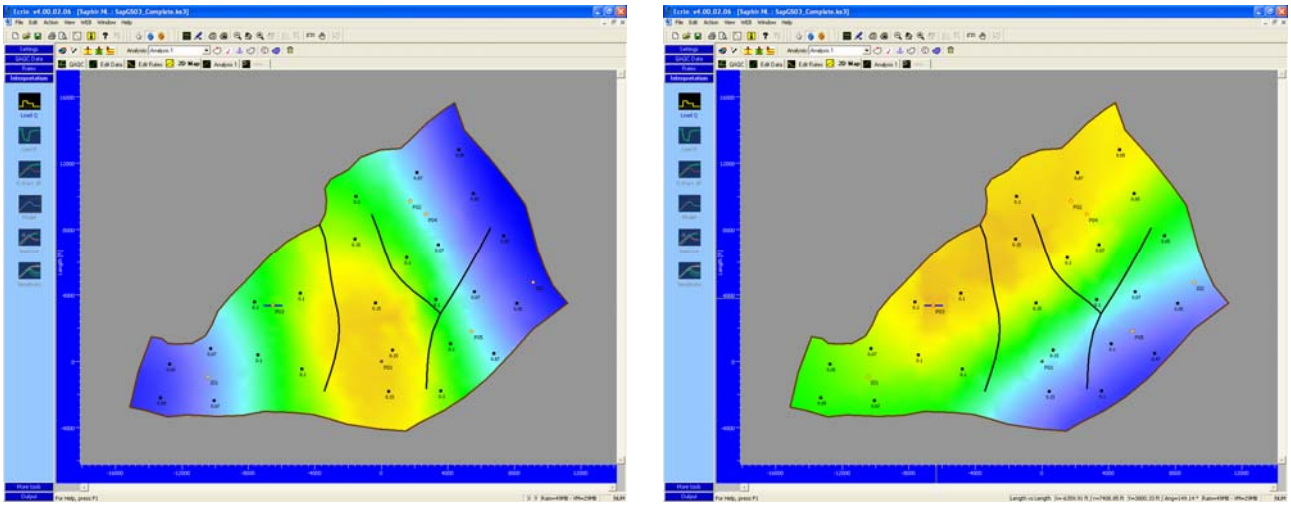


Fig D01.3 Porosity and thickness maps

Click on the model icon to display the numerical model dialog. The buttons h and Φ can be used to switch between thickness and porosity for the display of the 2D Map in the model dialog. Check “include thickness field” and “include porosity field” and make sure you have checked the option to store pressure fields, Fig D01.4 left. Generate the model. The response is now different to that of the original reservoir, Fig D01.4 right.

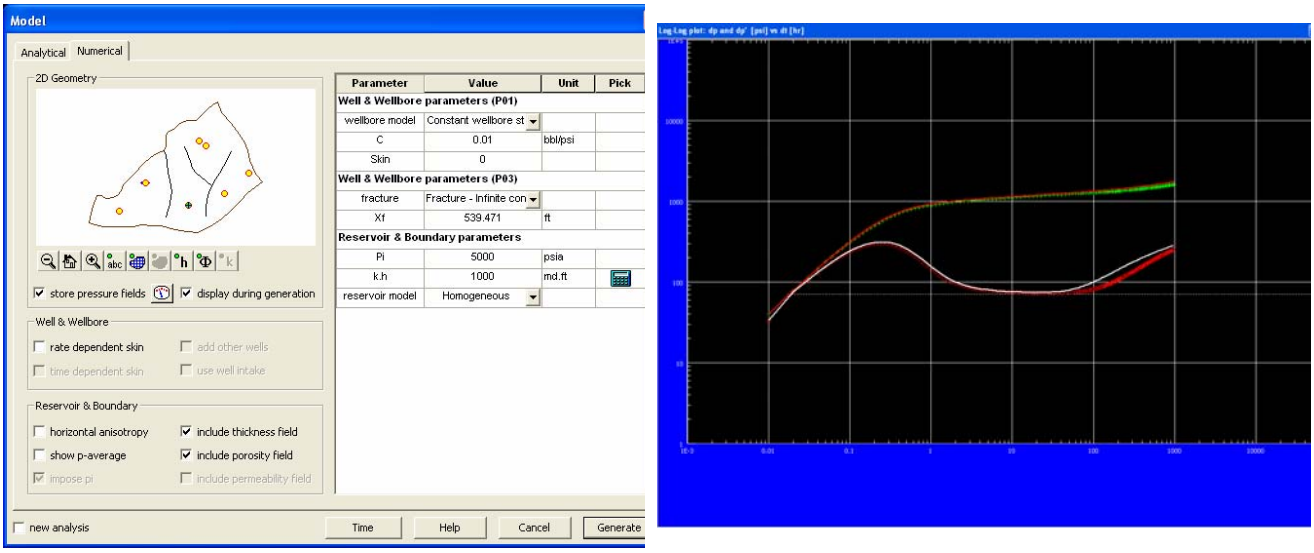


Fig D01.4 Model dialog and loglog response

Maximize the geometry plot. You can play back the evolution of the pressure fields if you wish. Use the  icon to create a cross section plane, illustrated in the 2D Map as a blue line Fig D01.5 left. Then click on  icon to create a 3D display of the model. The color shading represents the pressure value and the vertical scale the thickness. Fig D01.5 right. Use the settings  icon to change the 3D setup. In order to obtain a similar 3D display to that shown in the Fig D01.5 right, you may have to use the  icon, decrease vertical gain, and the  icon, increase vertical gain. The zoom options in the plot specific toolbar have a different behavior than the classical zoom options (click and drag):

 Zoom out,  Zoom reset,  Zoom in, nudges the graphics in and out.

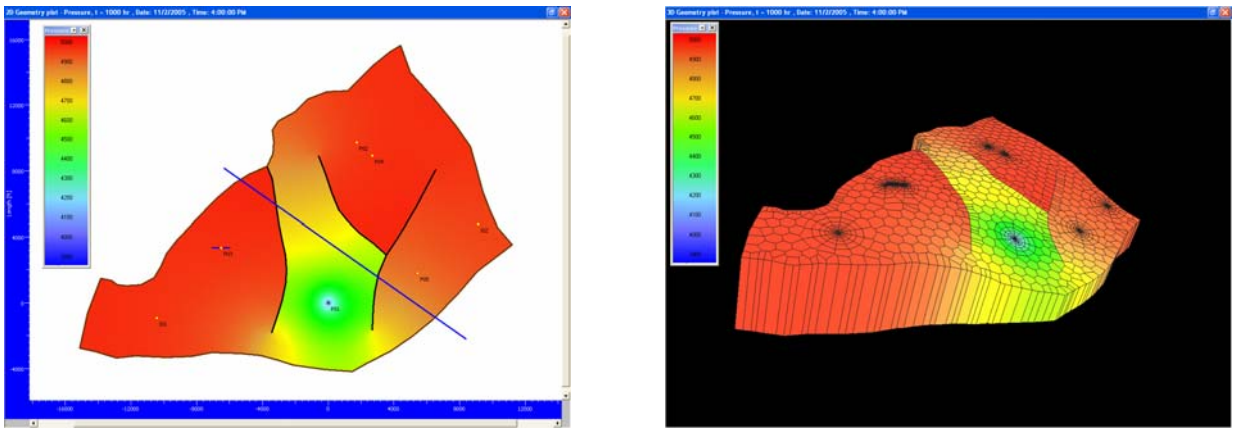


Fig D01.5 Building 3D display

Lets look at the cross section in 3- D that was defined by cross section plane blue line in the 2D Map. Click on the settings icon and choose the tab Cross Section planes, check the “Cross section trajectory (defined in 2D mode)” and play with the “erase before” (Fig D01.6 left) and “erase after” (Fig D01.6 right) check boxes.

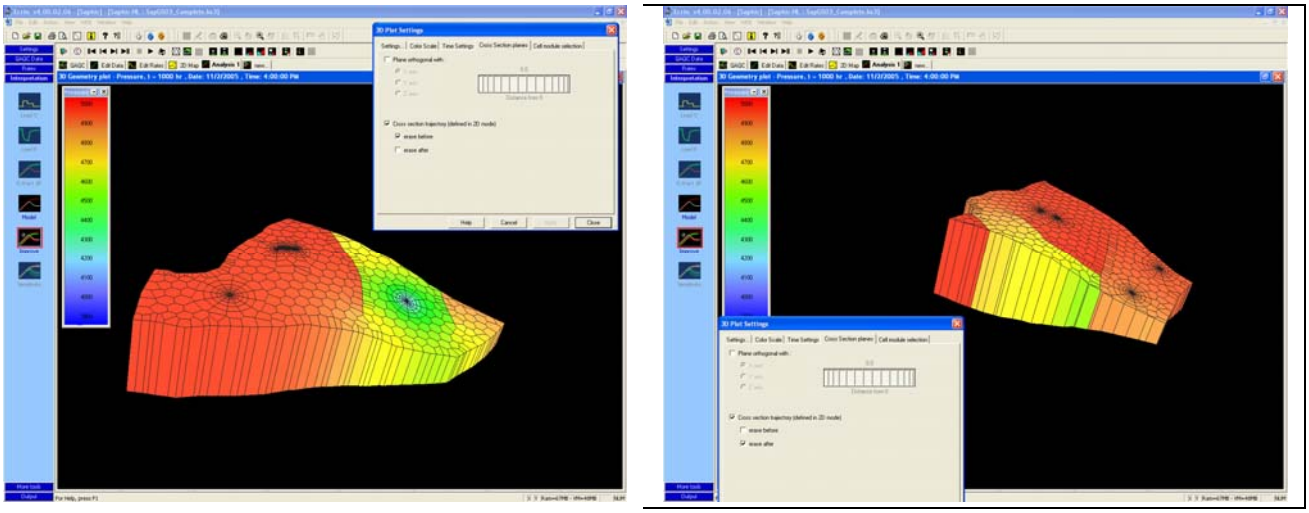


Fig D01.6 Cross sections

D01.5 • Other wells

Up to now only the tested well had a declared production and all the simulation runs were without the influence of any other well. The fact that well P03 was fractured was however, taken into account in all the runs. The simulation returns the response in the tested well, however the response in all the declared shut-in wells in the field is also accessible from the geometry plot by a double click on the well.

Lets define a production for well P03: 200 hrs 1500 STB/D, 200 hrs 5000 STB/D, 200 hrs 0 STB/D, 200 hrs 7000 STB/D, 200 hrs 0 STB/D. Double click on the well in the 2D Map and enter the rates manually in the Production tab. Click on the model and make sure you check the option “add other wells”, generate the response. The loglog response of the tested well is quite different to that of the system without other wells. Fig D01.7 right and the pressure response of P03 in Fig D01.7 left..

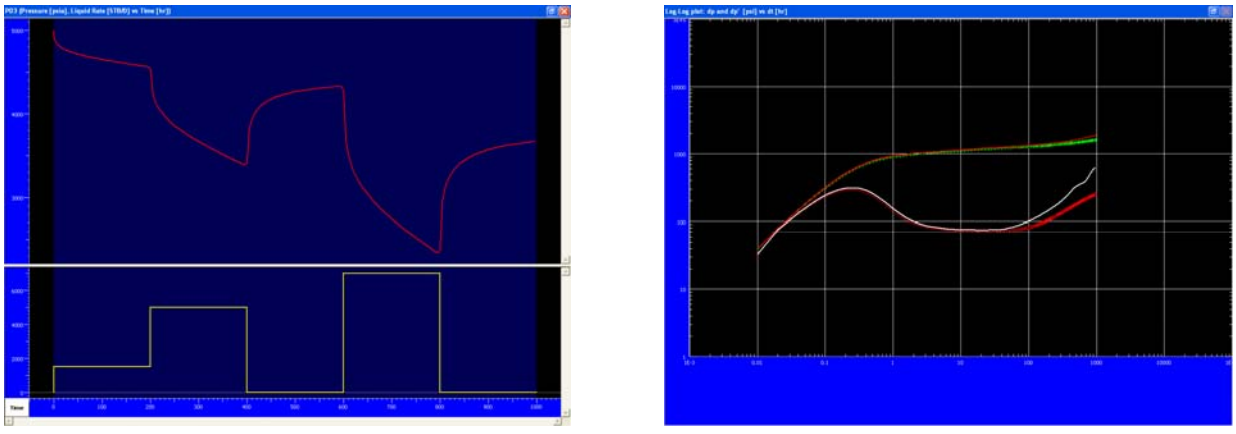


Fig D01.7 Loglog plot of response in P01 and linear response of P03