Topaze Guided Session # 1

A01 • Requirements

The guided tour provides a description of the facilities of Topaze through a synthetic oil example. We recommend that you follow this session before anything else.
The guided tour uses the files TopGS01.asc and TopGS01.rat located in the Examples sub-directory of your Topaze installation directory.

B01 • Creating a Topaze document

Start Topaze.
The main program window is displayed with a control panel to the left, several toolbars at the top, and an empty area that will subsequently be used for the plots. Every toolbar has a “grip control” (shown with 2 vertical lines) that can be used to drag the toolbar and dock it at a different position, or leave it as a “floating” toolbar inside the plotting area.

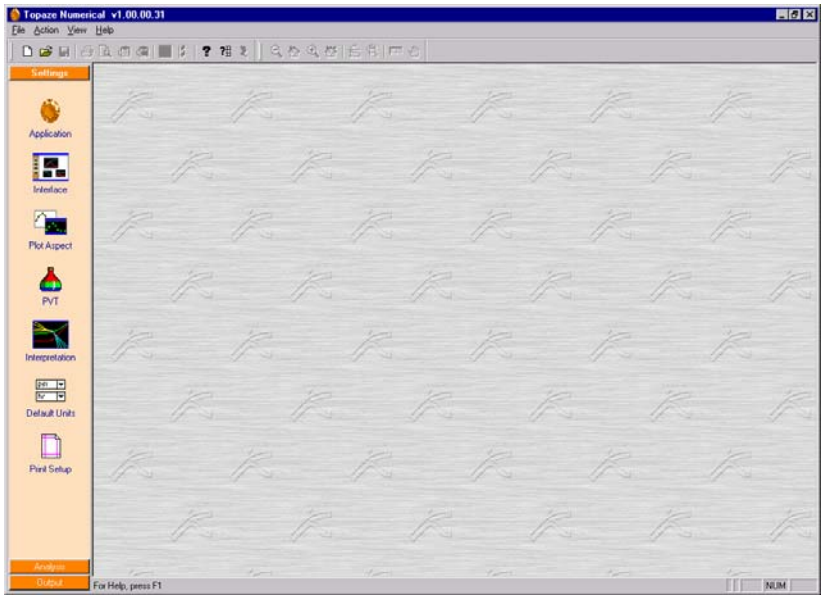


Fig B01.1 • Startup screen

The control panel contains 3 different “pages” that may be activated by clicking on the corresponding button: **Settings, Analysis** and **Output**.
When the mouse cursor is moved on top of any toolbar or control panel button, a brief description of the corresponding option appears in a popup window and in the status bar.
Settings is the open page when Topaze is started, this mode can be used to define permanent user settings. Create a new document using the **New** icon in the toolbar (or the New option in the File menu). The dialog in B01.2 is displayed with the 4 tabs:

Main options: Reference time, Fluid type, and basic test parameters.
Information: They can be typed in or pasted from the clipboard. They are printed in the report page.
Units: document units.
Comments: a text zone where any relevant information can be typed.

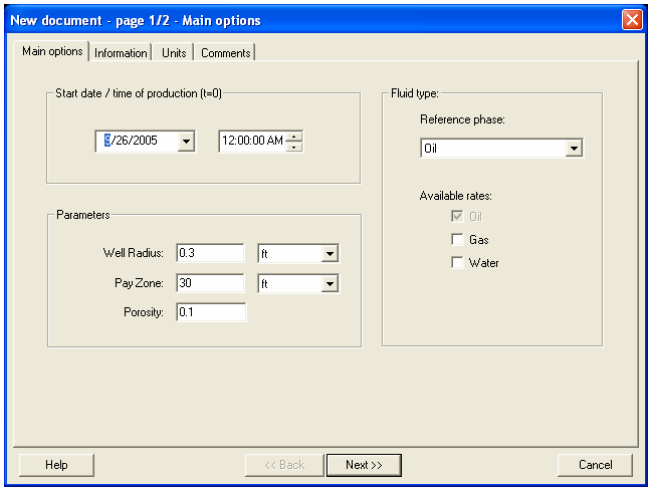


Fig B01.2 • Main options

Leave the reference phase as Oil, and keep the default test parameters, rw, h, and ϕ.

Press Next
The PVT parameter dialog is opened. In an Oil case, only the formation volume factor, the viscosity, and total compressibility are requested.

They can be input or calculated using  to invoke a Black Oil model.
Change B to 1.2, and the viscosity to 0.3
Create

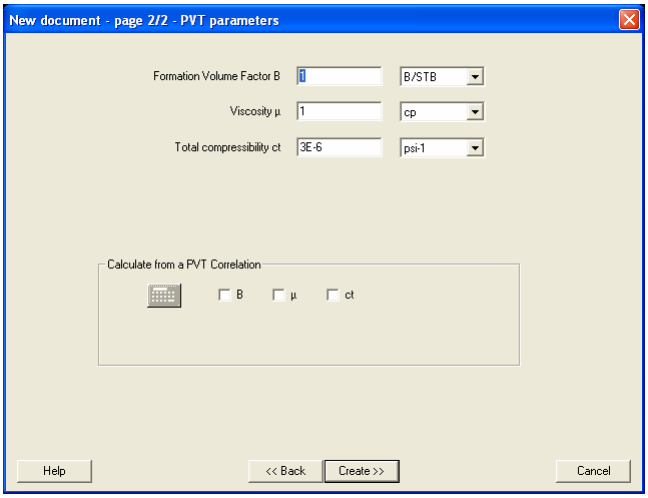


Fig B01.3 • Oil PVT parameters

The document is created and the control panel now shows the Analysis page, Fig B01.4. At the top of the main window are a new toolbar, and a series of tabs for accessing editing facilities, the 2-D map, etc. Those will be illustrated later.

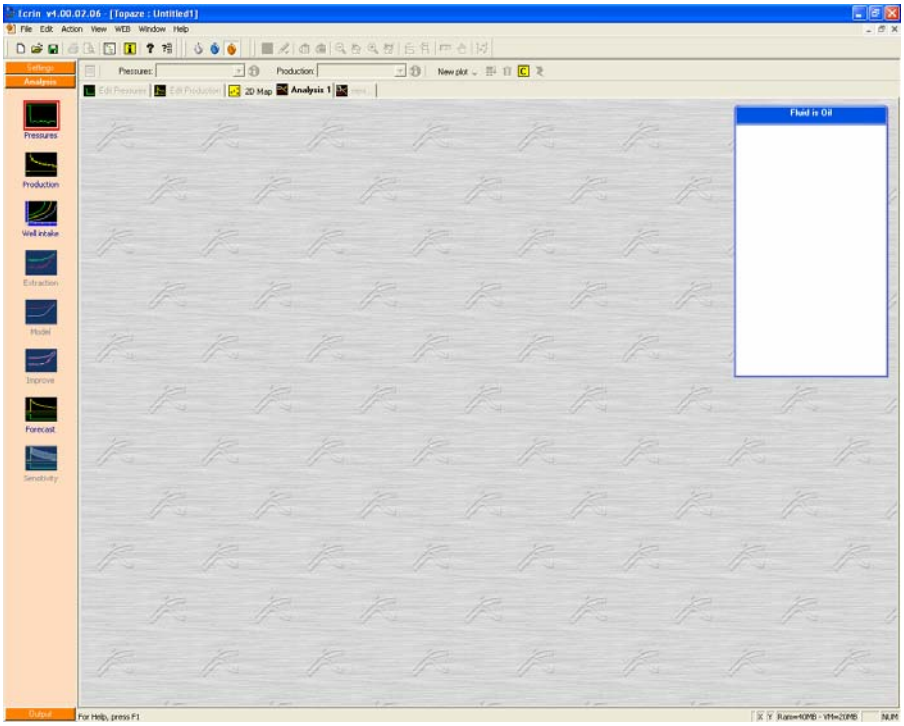


Fig B01.4 • Document created, Analysis panel activated

The Default path in Topaze makes use of both rate and pressure histories. Nevertheless as this section illustrates, it is possible to interpret rate data alone using conventional methods. Section 4.3 will show the additional options offered after the inclusion of a pressure gauge.

B01.1 • Loading and interpreting a production WITHOUT pressures

When loading data in Topaze one must know whether the data is defined by instantaneous values, or as steps. In the latter case, the times in the file can be treated as the duration of the steps, the time at the start, or the time at the end of the steps.

B01.2 • Loading a production

In this example, rates are defined by steps and duration.

Click on the Production option, the dialog in B01.5 is displayed.
Select ASCII file.
Open the files TopGS01.rat located in the Examples sub-directory, the Data Format dialog, Fig B01.6 appears.

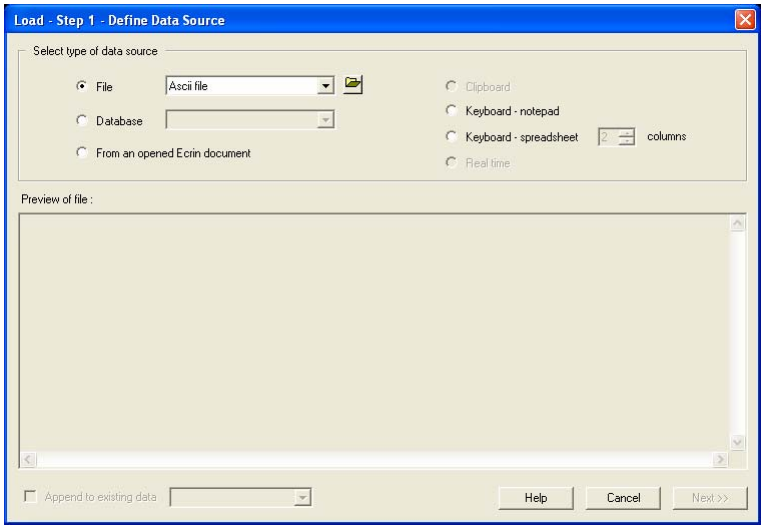


Fig B01.5 • Define data source

The file complies with “free format”, i.e. 2 decimal numbers per line and Topaze identifies automatically the time and rate fields.
Choose “Step: duration”.
In a more complex situation, one could use the header buttons in the grid, to define the various fields in the file. Alternatively, the definition could be based on column range rather than fields (column tab). Please refer to the on-line help or software reference for details.
The defaults are fine. Click Load.

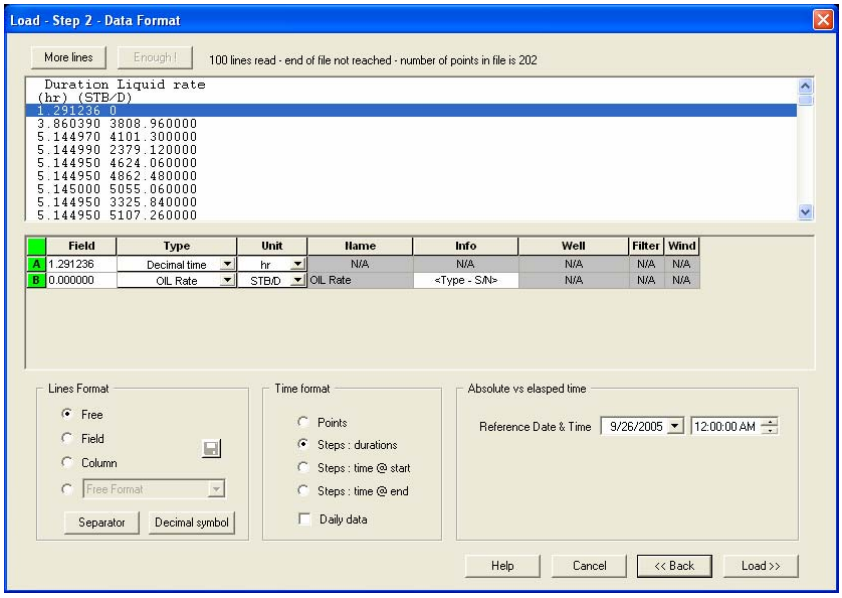


Fig B01.6 • Data format

A production history plot is automatically created with the rate in yellow, and the cumulative production in orange (all defaults can be changed in Settings – Plot Aspect). In the second toolbar from the top, the “Production” list now shows B01, the rate gauge we have just loaded.
The bottom part of the history plot is meant to display a pressure gauge and it will therefore remain empty for the time being.

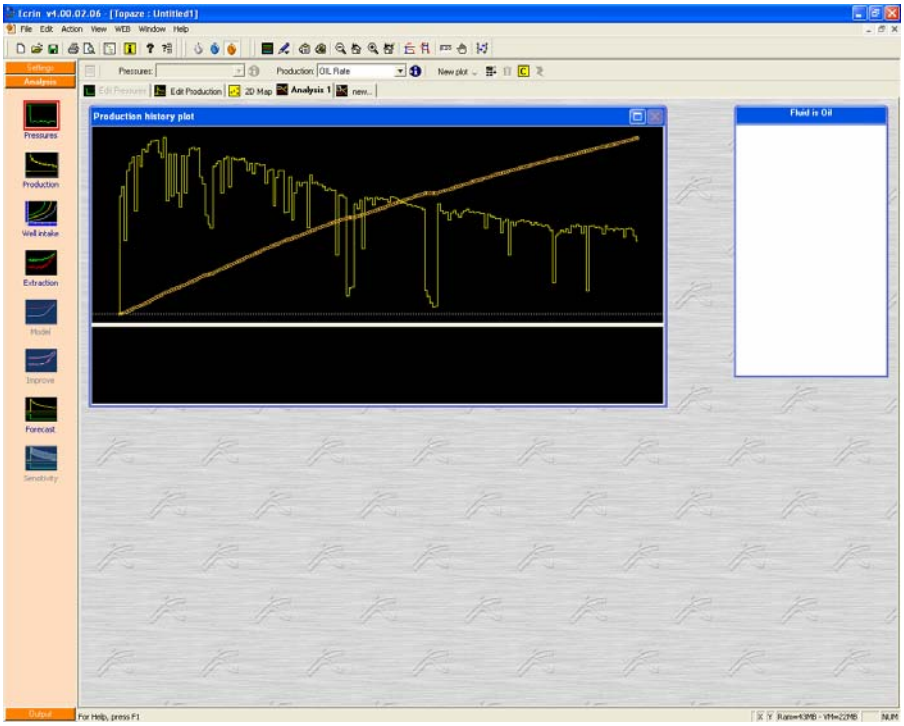
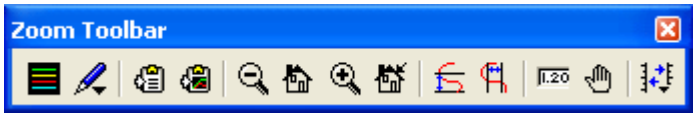


Fig B01.7 • Production loaded

A plot can be rescaled using the zoom toolbar: 

Zoom Out, Restore default, Zoom In, Set Default, Interactive on Y, Interactive on X, Manual, Shift.

A plot can be maximized with a double click. Specific options can be accessed in maximized mode with a dedicated toolbar, or at any stage by a right click on the plot. All toolbar icons have associated tooltips: if you move the mouse cursor on top of an icon (without clicking) the tooltip will appear to give a brief description of the option.

B01.3 • "Extracting" a time range for analysis

Select Extraction.

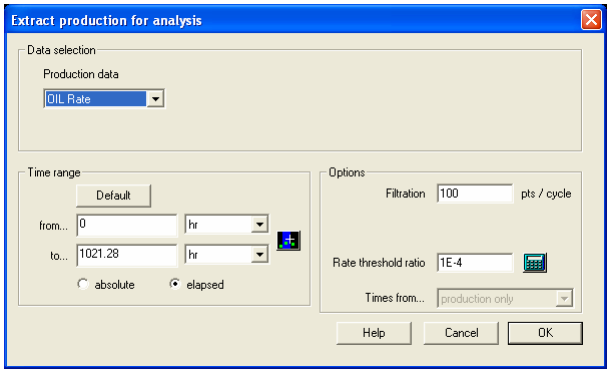


Fig B01.8 • Extraction dialog

The “Extraction” step amounts to selecting a rate channel, and possibly a pressure gauge for interpretation, and a time range. In addition, as several diagnostic plots use a log of time, a logarithmic filtration of the data is offered. This is mainly useful when both rates and pressure are loaded. When only rates are present, the analysis plots display by default the full history (not the sampled version), unless there is a large number of points.
Accept the default for the Extraction and validate with OK.

Among the plots that Topaze will create by default for the analysis is a Fetkovich Type-Curve plots. Some of the results in this plot are linked to values of Pi, initial reservoir pressure, and Pw, well flowing pressure. When no pressure gauge is loaded, the user is prompted to enter those values. If no input is given (i.e. values stay absent) the plot is not created.

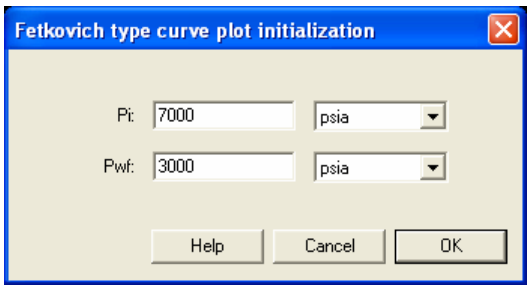


Fig B01.9 • Fetkovich Type-Curve plot input

Validate with OK. Two new plots are created: Fetkovich Type-Curve and ARPS.

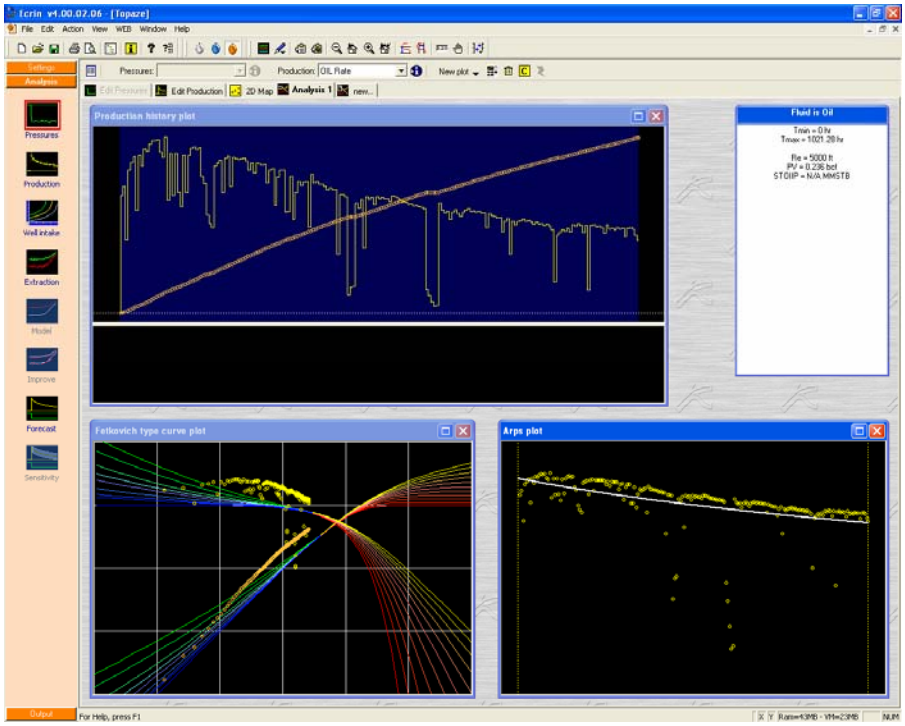


Fig B01.10 • Extraction done

B01.4 Arps analysis

Maximize the plot with a double click on its title bar, Fig B01.11.

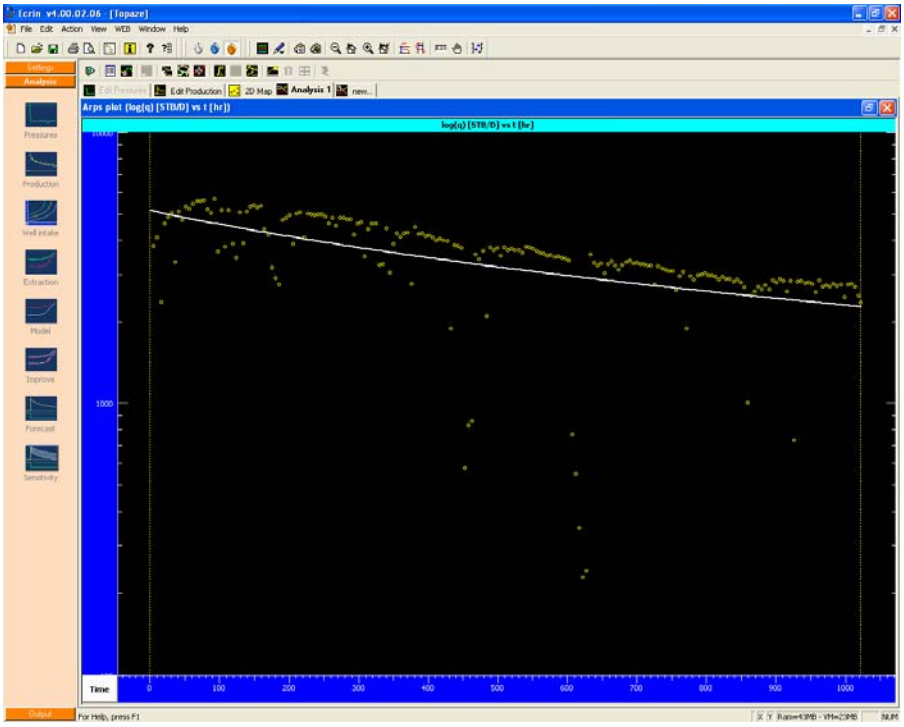


Fig B01.11 • Arps plot maximized

This plot is dedicated to matching the production with a decline of type: $q(t) = \frac{q_i}{\left[1 + bD_i t\right]^{\frac{1}{b}}}$

Where q_i is the initial rate, D_i the decline factor, and b, comprised in [0, 1] determines the decline type. Harmonic decline corresponds to a b value of 1, exponential decline to (the limit of) the above expression for b equal to 0: $q(t) = q_i \times e^{-D_i t}$.

When the plot is created, Topaze runs a non-linear regression seeking the values of b, Di, and qi that provide the best fit of the data**,** and the corresponding decline curve is plotted in white.

Parameters direct input

Use the results icon of the toolbar (or a right click in the plot) to access the dialog and change the values directly. This dialog is also used to specify the extent of the decline curve on the plot, and the abandonment criterion, which will affect the results.

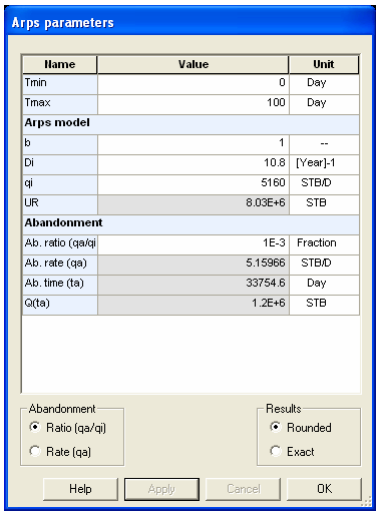


Fig B01.12 • Parameters

Lasso option

With the lasso option you can have Topaze calculate all three parameters or simply qi and Di. On the plot you can define one or several areas. Topaze then runs a regression to find the optimum parameters to match the data on your selections.

Parameters interactive modification

Accessible from the toolbar or the popup menu with “Modify”, this option lets you grab the decline curve on the plot, and modify the parameters as you move the mouse in the plot:
Up/ down moves change qi.
Left/right moves change Di.
Up/down moves with the Shift key pressed change b.

The following options are also implemented:

Plot type

The plot scale can be set to: q vs t, log(q) vs t (default), log(q) vs log(t), q vs Q, log(q) vs Q.

Add Plot

Show model

The display of the simulated rate/cumulative can be toggled on/off (off by default).

Show cumulative

When relevant, the cumulative can be displayed (data and decline curve).

Sample/filtered data
With less than 1000 rate points the plot shows by default the actual data. When more points are present the sampled version, based on the number of points per cycle given in the extraction dialog, is used.

Change the scale to q vs t and Show the cumulative, Fig B01.13.

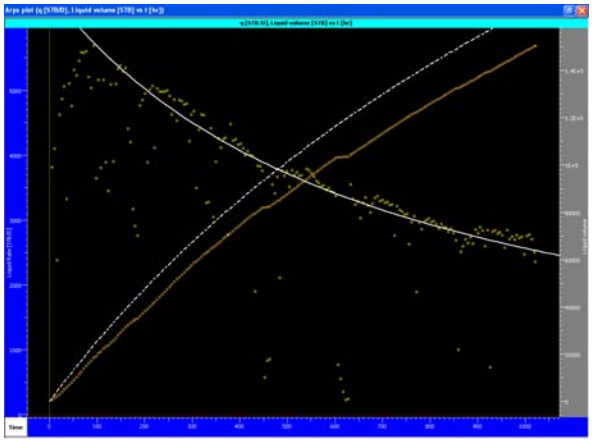


Fig B01.13 • Linear scale, q and Q displayed

On this scale we see that the match requires some adjustments.
First change b to 0, i.e. exponential decline. Then, adjust qi and Di for a better match. You can use the Drag option , or the popup option “Modify” until a satisfactory match is found, e.g. Fig B01.14.

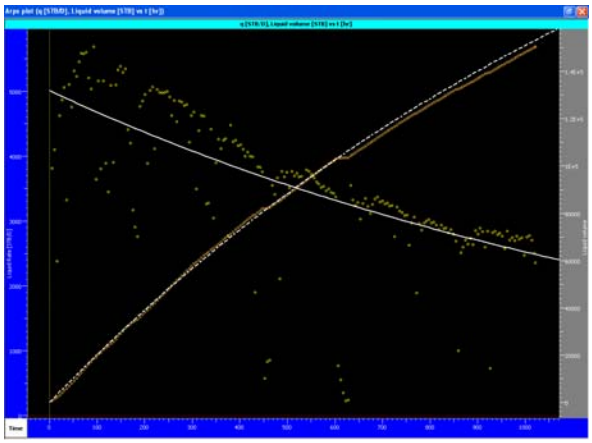


Fig B01.14 • Match modified

Display the Results Fig B01.15
An Ultimate Recovery noted UR is given. This would be the recovery for an infinite production time.
An abandonment time is calculated based on the input qa or qa/qi.
The cumulative production at the abandonment time is reported as Q(ta).
Note that on the plot, a red horizontal line shows the value of qa, the abandonment rate.
If you modify the decline curve with the results in display, they are continuously updated.

Return to the main screen with

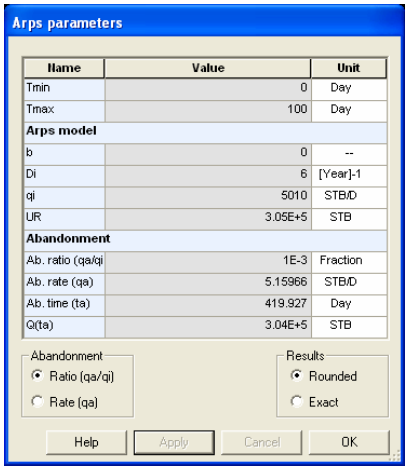
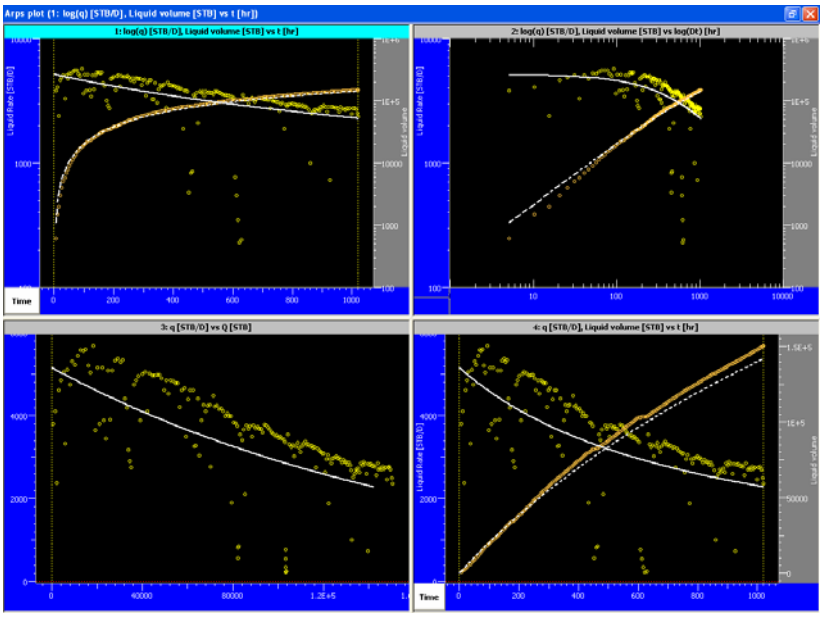


Fig B01.15

Click on to add a plot. This option allows you to add Arps plots with a different scales and diplay the plots together. The will tile the plots. See Fig B01.15A.


Fig B01.15A Multiple Arps plots

B01.5 Fetkovich Type Curve

Maximize the Fetkovich Type-Curve plot.
This plot combines 2 families of Type-Curves; the Arps decline curves to the right, and a transient part to the left for a well in a circle. Since a Pi and flowing pressure have been entered, the Fetkovich plot can be used to get an estimate of kh and Re.

A legend can be displayed using the icon. In addition, the parameter associated with every curve can be seen when moving the cursor on top of them.
When the plot is created, Topaze runs a non-linear regression to find a match point. The match values can be seen in the Results dialog. The match can be modified by dragging directly the data on the plot.
To drag, simply click the left button inside the plot area, keep the button pressed, and move the mouse.

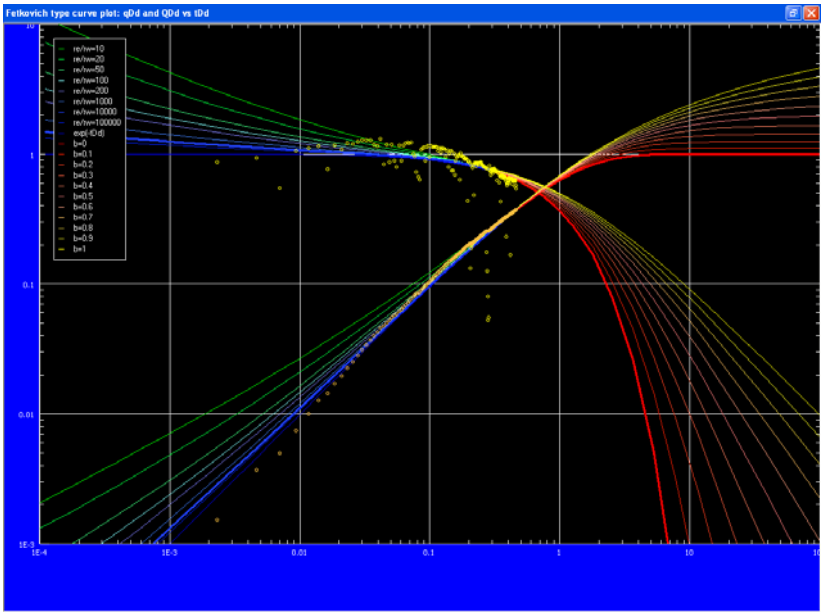
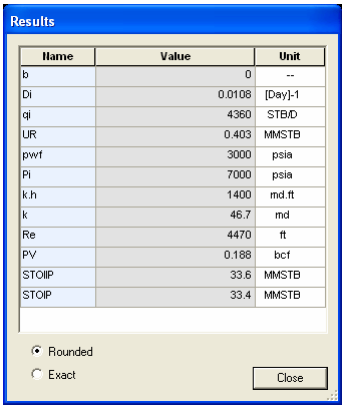


Fig B01.16 • Match modified

Check the results.
At the top you will see the Arps results, b, Di, qi and the corresponding ultimate recovery, UR.
Next are the results linked to the transient part of the match: kh (permeability-thickness product), Re (external boundary distance assuming a circle).
From Re, an area is obtained and from the input of thickness and porosity made at the file creation, a Pore Volume PV is calculated. With PV and the formation volume factor the Stock Tank Oil Initially in Place (STOIIP) is derived. Finally the last cumulative value is subtracted from STOIIP to get the Stock Tank Oil In Place, STOIP.



B01.17

The match above is made along the exponential decline (Topaze uses a thick line to highlight the closest fit). If the Arps analysis is also made with a b value of 0, similar values of ultimate recovery are obtained.
Return to the main screen after checking the results
A pressure gauge could be loaded as this stage and Topaze would offer to re-extract, using this time both information. In order to show the default path, we will however restart a case from scratch.
Close the file without saving.

C01 • New document with pressures and rates

Create a New file, and in the Init sequence simply change B to 1.2 and the viscosity to 0.3

Select the Pressures option.
Open the file TopGS01.asc
Since the format and units are all in agreement with the defaults, select Load points.

In the next dialog, the initial value of the pressure gauge must be set.

Use the  icon to set Pinit to the maximum pressure in the gauge, 5650 psi, and press OK.

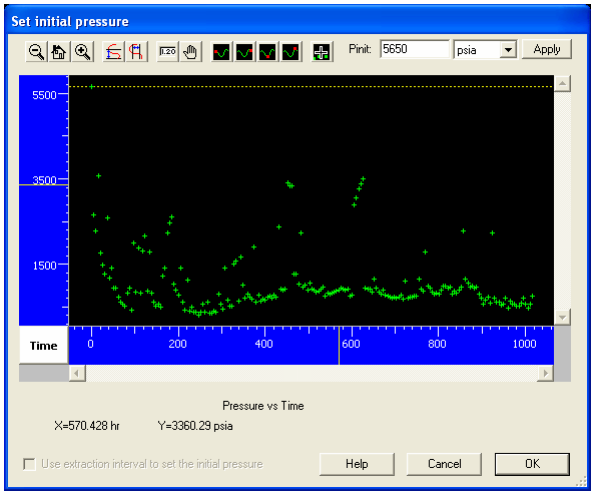


Fig C01.1 • Setting Pinit

Open the file TopGS01.rat
Select the Production option, remember to select the “Steps: duration” option.
Since the format and units are all in agreement with the free format, select Load.

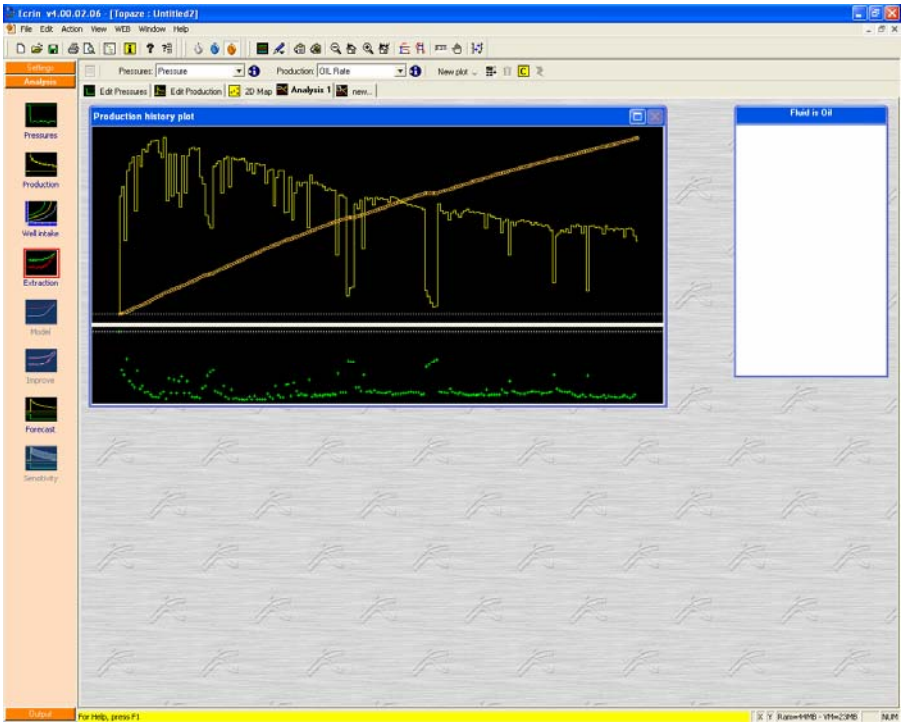
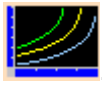


Fig C01.2 • Pressure and Rate loaded

The pressure values we loaded have been recorded at wellhead. For the analysis however, we will need bottom-hole pressures. The Intake option of the control panel can be used to convert from wellhead to sandface, using either internal pressure drop correlations, or user supplied lift curves.

Select the Well Intake option of the control panel .

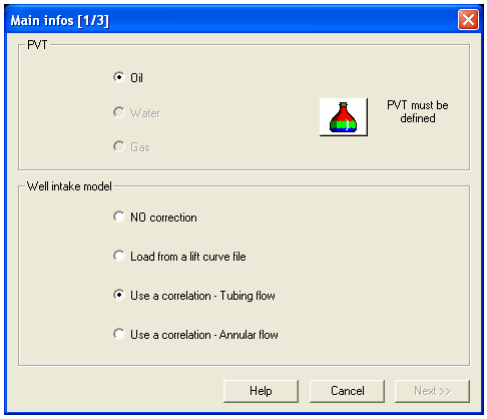


Fig C01.3 • Intake init

Select correlation and tubing flow, a PVT icon appears indicating that the calculation needs a PVT model. Note that in gas, or if the PVT model has been called at startup to get an estimate of the parameters, the input will not be required at this stage.
Click on the PVT icon to define the fluid type and fluid properties.

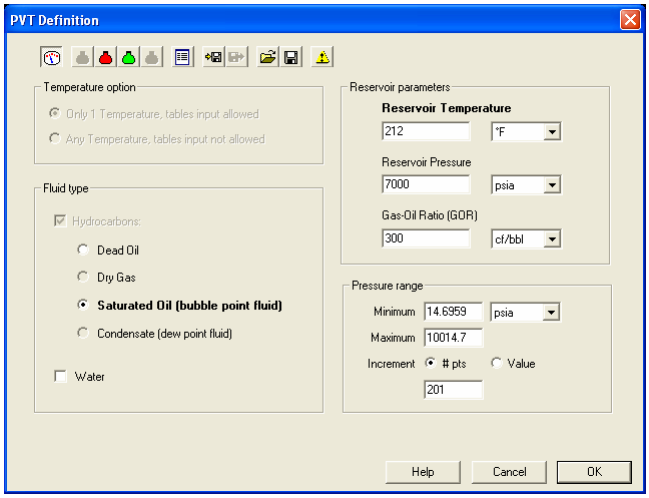


Fig C01.4 • PVT init

Change the GOR to 300 cf/bbl, and the reservoir pressure to 7000 psia.

Using the phase icon  in turn to check the gas and oil settings. Do not change the correlations or input values.

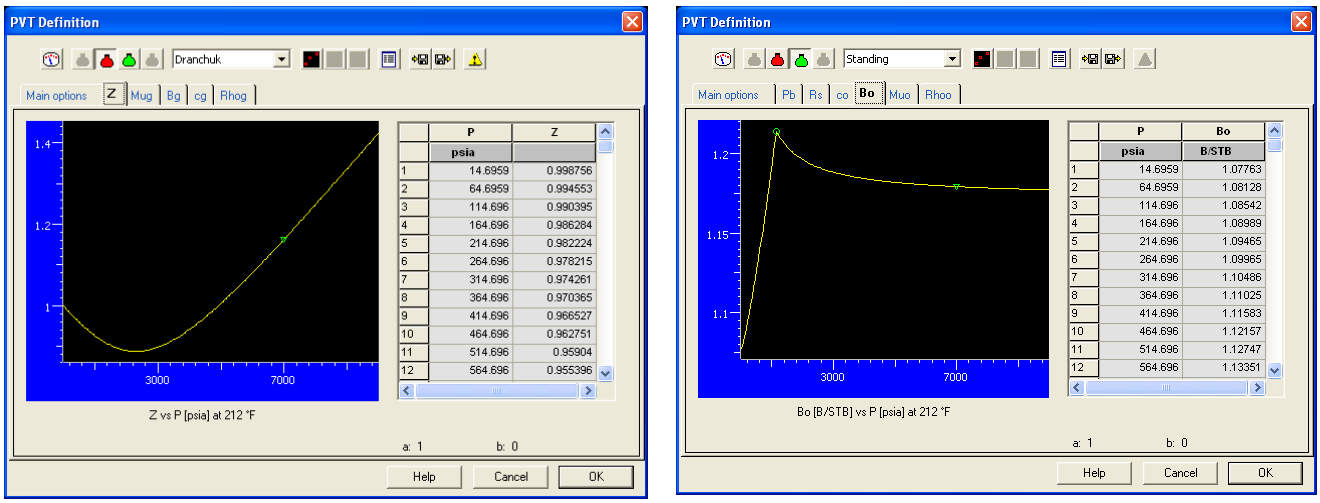


Fig C01.5 • View/edit PVT properties

When the PVT input is completed you are back to the Intake Main Infos dialog.
Click Next to access the Flow Parameters dialog. Change the bottom-hole depth to 5000 ft, the GOR to 300.
Note that this GOR value is an independent input representing the production split.
Click Next. A plot of P at bottom-hole versus rate is generated for an entered wellhead pressure. This is given for information only.
Click OK.

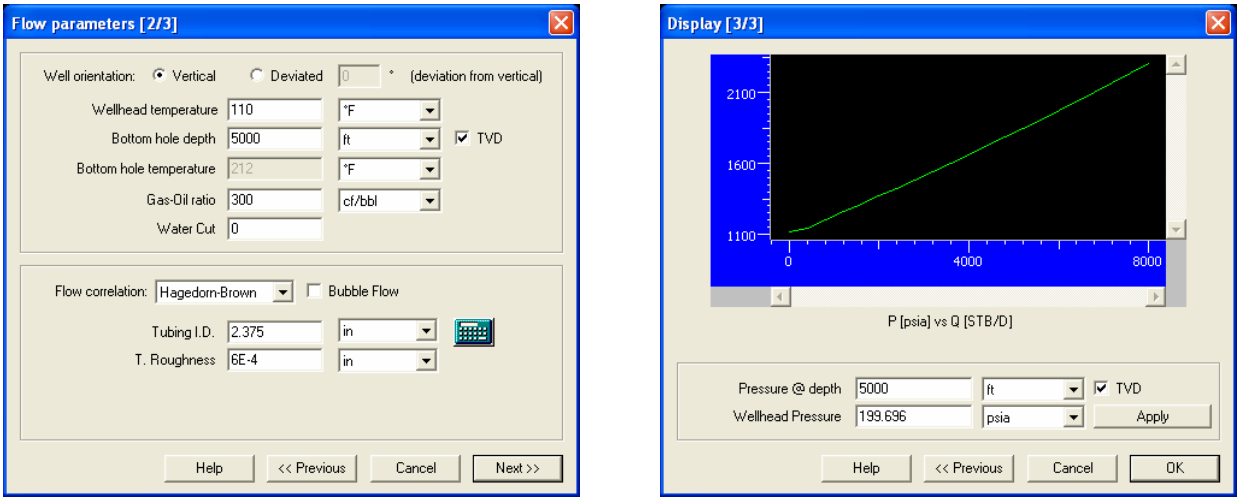


Fig C01.6 • Pressure drop correlation input

The intake model is now created. No correction has been done to the pressure gauge yet as this will be part of the Extraction step, see the next section.

C01.1 • Extraction

Select “Extraction”

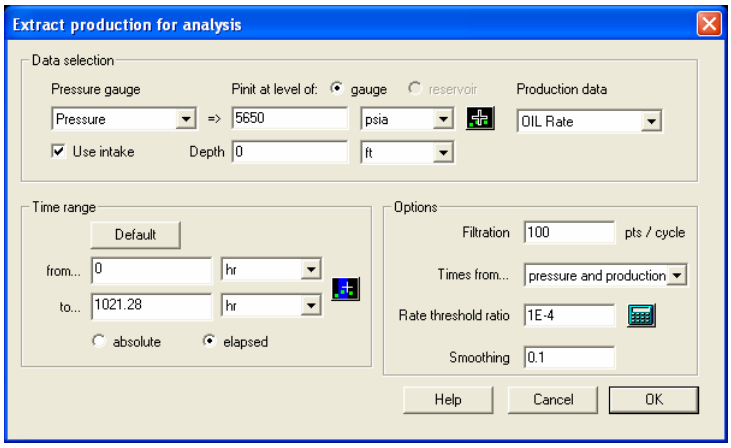


Fig C01.7 • Extraction with Pressure and Rate

Check the box ”Use Intake”, and note that the gauge depth is 0, i.e. wellhead. For the rest, you can accept the defaults.

Note that the data sets will be “extracted” at the times of both pressure and rate histories. Practically, this means that both data sets will be interpolated if necessary at those times. When OK is given, a progress bar appears as the pressure correction takes place, and the analysis plots are created. From that point onwards the analysis will work with, and display, the corrected pressure values. If you go to the “Edit Pressure” tab, however, Topaze will access the wellhead values. If you make any change affecting the pressure correction (change the intake model, the production history, the original gauge, etc) Topaze will re-compute the correction.

In addition to the previous plots, Topaze creates the followings: loglog plot, Blasingame plot, Fetkovich plot and a normalized rate cumulative plot. Note that the creation is based on the application Settings. In “Settings-Interpretation”, it is possible to change the default creation.

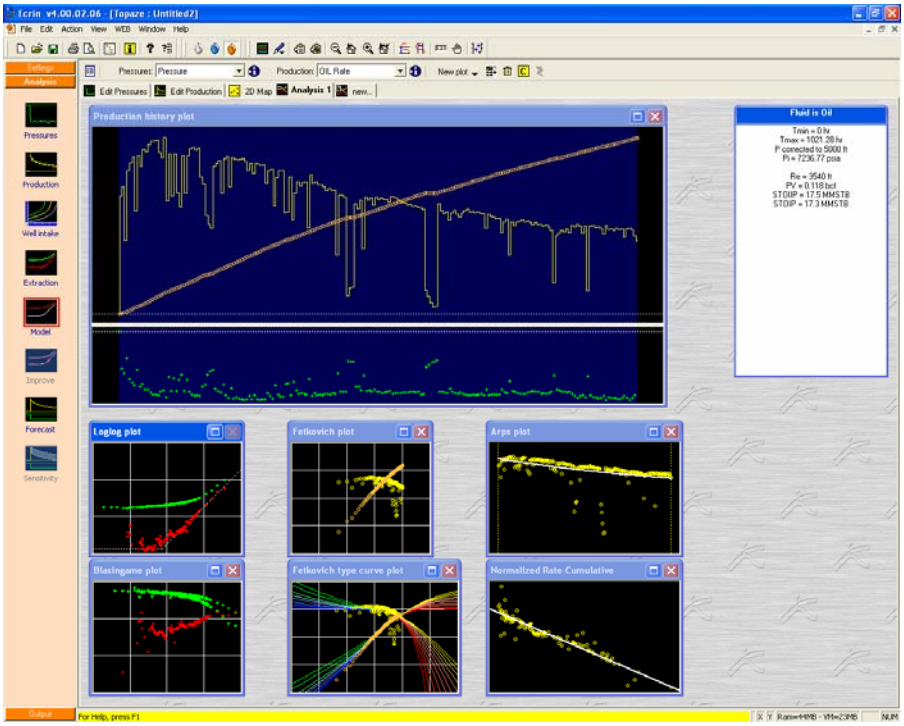


Fig C01.8 • Extraction done

Since we have seen Arps and Fetkovich Type-Curve plots in the previous section, we will delete them by clicking their close box (at the top right of their title bars). The remaining plots are reviewed below.

Fetkovich plot

This is a log-log display of rate and cumulative versus time, in real units. The presentation is similar to that of the Fetkovich Type-Curve plot, but the new one will serve for a comparison between model and data. Drag options are implemented for this purpose, and will be illustrated later.

Blasingame plot

The x-axis of the Blasingame plot is an equivalent time defined as: $t_e = \frac{Q(t)}{q(t)}$

The plotted channels are:

With triangles in green (gauge color), an instantaneous productivity index:

$$\text{PI} = \frac{q(t)}{p_i - p(t)}$$

With plus signs in green (gauge color), the integral of the previous function divided by the time:

$$\text{PI Int.} = \frac{1}{t_e}\int_O^{t_e} \frac{q(\tau).d\tau}{p_i - p(\tau)}$$

With plus signs in red, the derivative of “PI Int” with respect to the log of equivalent time.

The essential feature of this presentation is that even in the case of changing pressure, the boundary dominated flow period will exhibit a –1 slope on all three channels. In addition, PI Int and its derivative will merge together during that period. By plotting a given model on the same scale and with adequate drag options, this plot will allow refining the model parameters.

Loglog plot

The loglog plot is almost an inverted Blasingame plot. The x-axis is the equivalent time, and channels plotted by default are:

With plus signs in green (gauge color), the integral of a rate normalized pressure, divided by the time:

Normalized pressure integral = $\frac{1}{t_e}\int_o^{t_e}\frac{p_i - p(\tau)}{q(\tau)}.d\tau$

With plus signs in red, the derivative of the previous function with respect to the log of equivalent time.

It is also possible to plot the rate normalized pressure, rather than its integral, but this function is usually too noisy hence the default usage of the integral.

Normalized pressure = $\frac{p_i - p(t)}{q(t)}$

During boundary-dominated flow, both the pressure integral and its derivative exhibit a straight line of unit slope, similar to a pseudo-steady state regime in a pressure transient interpretation. The similarity goes further and one can check that other flow regimes appear – at least on test designs – with the same signature as for constant rate solutions.

The methods traditionally used in Pressure Transient Interpretation can thus be applied on the loglog plot. In particular, a stabilization of the derivative can provide and estimate of kh and the late time unit slope, when seen, can readily provide an estimate of Re. This is illustrated below.

Normalized rate cumulative plot

Another plot that can be created is the “Normalized rate cumulative ” plot. In oil, this option creates a plot of normalized rate versus normalized cumulative:

$\frac{q}{p_i - p_w}$ versus $\frac{Q}{c_t(p_i - p_w)}$

With an exponential decline, a linearity is seen and its intercept with the X-axis is gives the initial fluid volume in place.

In gas, the variation of the PVT properties cannot be disregarded and this variation requires a prior estimate of the gas in place, and therefore an iterative solution. The plot displays:

$\frac{q}{m(p_i) - m(p_w)}$ versus $Q_{DA} = \frac{G_i.\left[m(p_i) - m(\overline{p})\right]}{\left[m(p_i) - m(p_w)\right]}$

The value of "X" at the intercept is Gi.

On the Normalized Rate-Cumulative plot a line can be created, either by regression or drawn. This line may then be modified interactively.

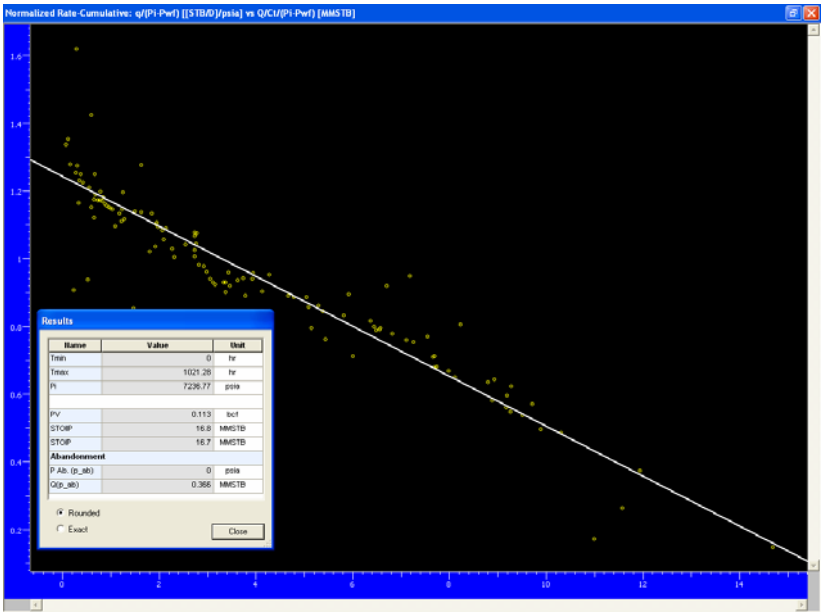


Fig C01.9 • Normalized Rate –Cumulative plot results

C01.2 • Loglog match point

Maximize the loglog plot.

Two lines have been set automatically by Topaze on the plot: a horizontal line, corresponding to radial flow and giving an estimate of kh, and a unit slope line, set through the boundary dominated flow period, and providing an estimate of Re.

Check the results. They include kh and Re thus obtained. Re is used to calculate the pore volume (PV) hence the STOIIP and current STOIP subtracting the last known cumulative.

By click and drag on the plot, you can change the line position, and see the results being updated. If you move the match, you can reset it to the original position wit the “Reset Match” button .

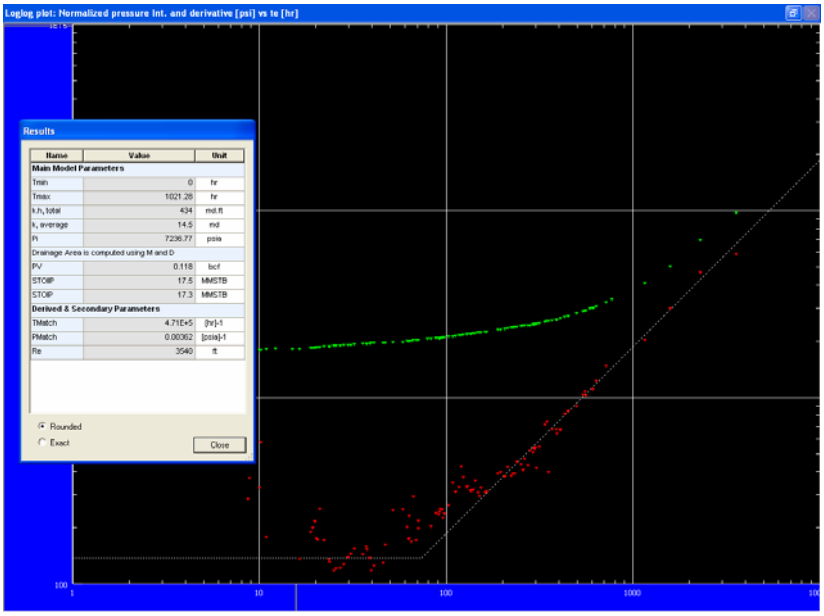


Fig C01.10 • Loglog match results

Note the specific loglog options accessible in the toolbar:

 Reset match: restore the original position of the match lines

 Smoothing: change the smoothing used for derivative calculations.



Change the pressure function in display, Normalized pressure, or Normalized pressure integral.

Leave the loglog plot and return to the main screen.

C01.3 • Modeling the response

From the match lines, we obtained an estimate of the reservoir permeability and size. We may now use those values and simulate the rate response of a well with storage and skin, subject to the input pressure history. Click on Model, the dialog on Fig 01.11 is displayed

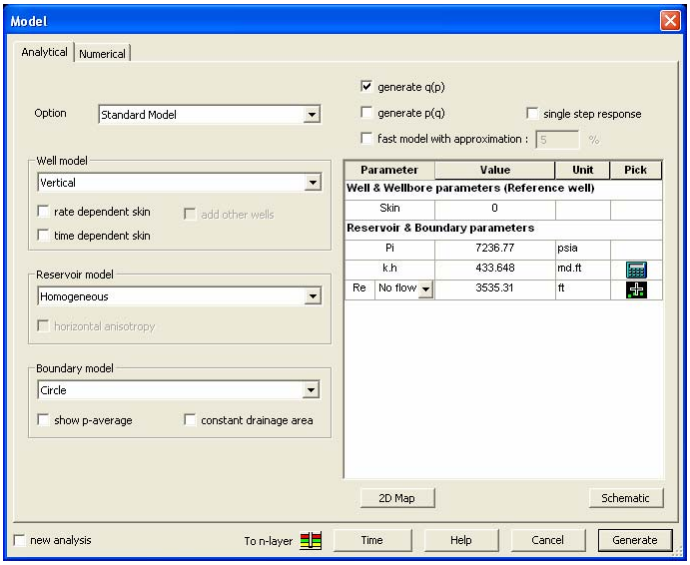


Fig C01.11 • Model dialog

By default, the model is set to Analytical, but we could also invoke a 2-D Numerical (see session TopGS02). The default model is for a vertical well in a homogeneous circular reservoir. kh and Re come from the current match point on the loglog plot. Pi comes from our earlier choice, i.e. the maximum gauge value, which was converted to bottom-hole. The skin was estimated automatically from the loglog plot.
Select Generate.
The model rates/cumulative are displayed on the history plot in red. The model is also added on the loglog, Blasingame, and Fetkovich plots. On loglog and Blasingame plots the model appears rather erratic and this is essentially due to the time function used, te = Q/q which is not guaranteed to be monotonous.

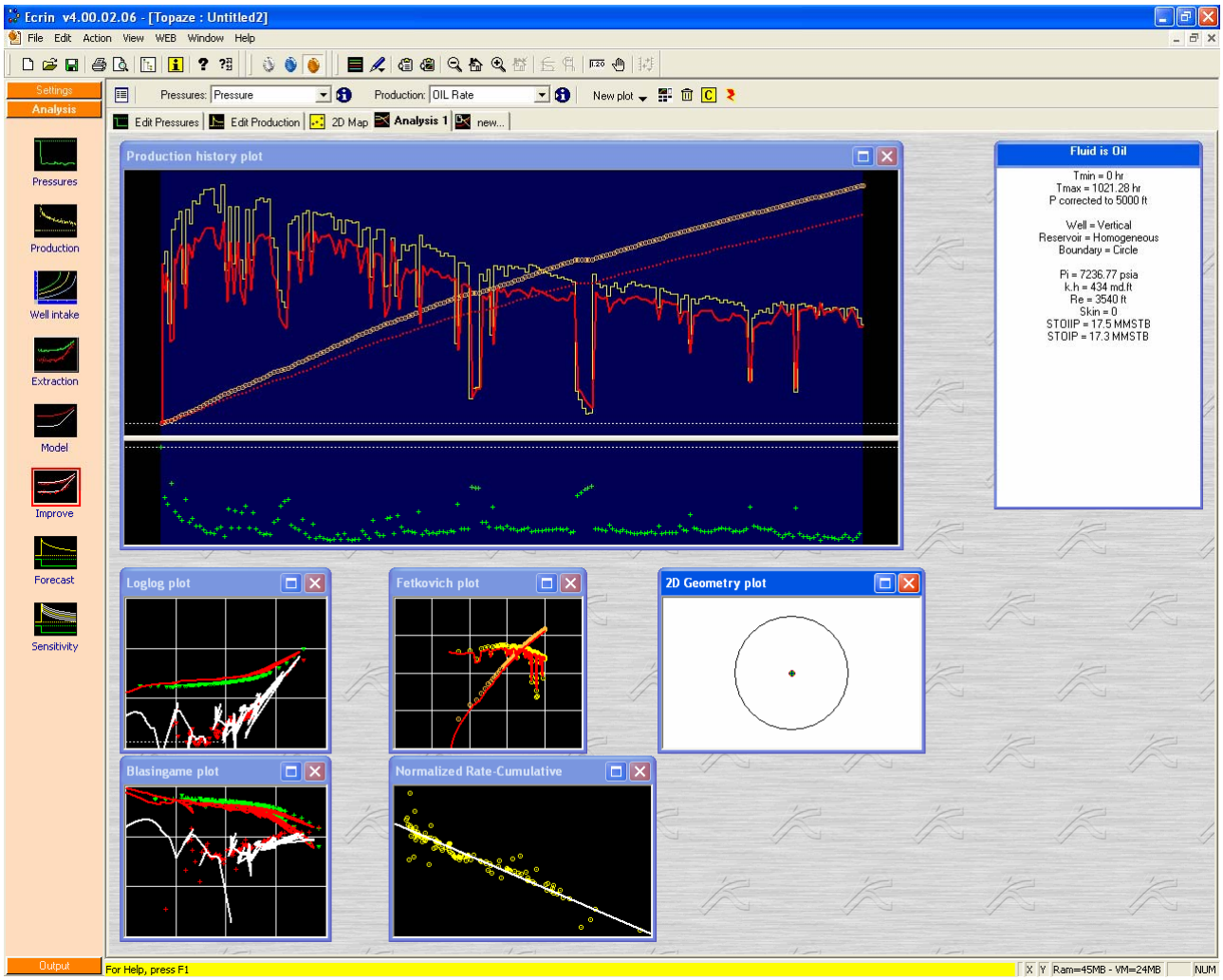


Fig C01.12 • First model estimate

The default time sampling for the model uses both the times of the production and pressure histories. With large data sets this may cause the model to be too slow. Topaze will change the sampling when a maximum number of points (defined in the “Settings-Interpretation-Data Control” option; default 500) is reached. The Time sampling can be modified manually with the “Time” button in the model menu.

Return to the Model menu.
Check the box “generate p(q)”
Check the box “single step response”
Generate

Click on the pressure part of the history plot, and the click on  to recalculate the default scale.

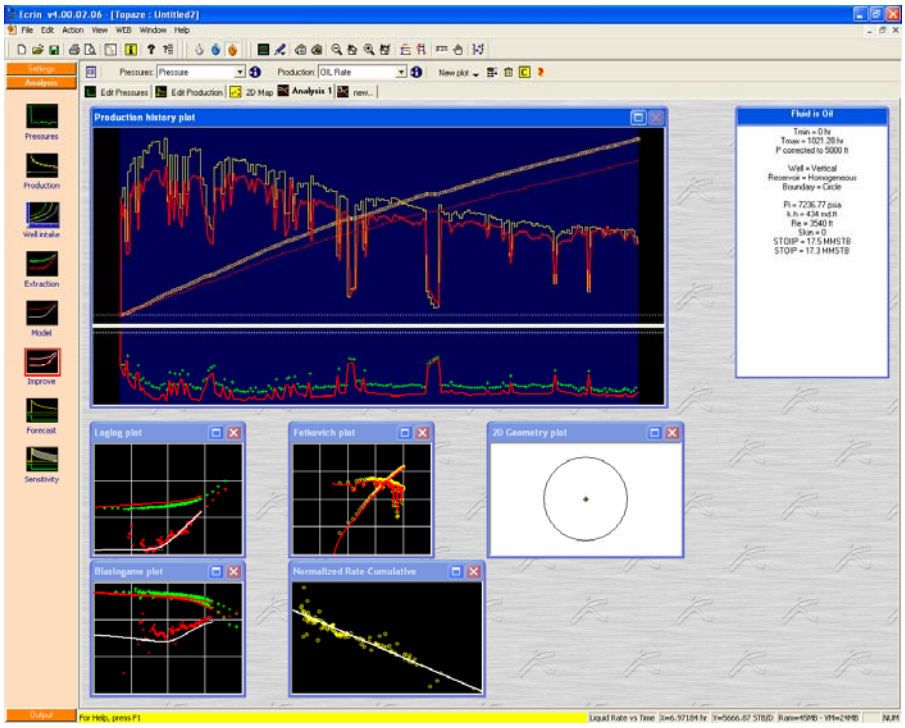


Fig C01.13 • Rates /cumulative and pressure generated; Single step loglog display

On the history plot, pressure simulated from the input rates is displayed. Also on the loglog and Blasingame plots, the model response is now smooth. This is because what is displayed is only the response to a single pressure.
Each of the 3 plots (Fetkovich, loglog, and Blasingame) includes drag options. When the model is dragged on one of them, the change is reflected on the others. You can experiment with the drag on the main screen. Note that the drag does not affect the simulation itself, i.e. the model on the history plot. To validate a drag, the model should be re-generated with the new parameters. A shortcut for doing this is the toolbar icon 
Right click on the loglog and select “Reset match” when you are done so that we are back to the original match point.
If you do not reset the match, a drag should always be followed by a new generation of the model to update the history plot.

C01.4 • Improve

This option calls a nonlinear regression algorithm that will adjust the desired model parameters, in order to match the rate and/or the cumulative and/or the pressure.

Select Improve

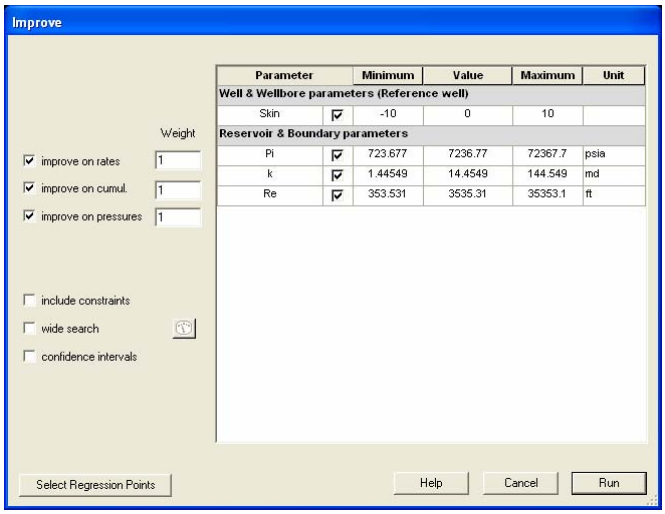


Fig C01.14 • Improve dialog

The error between the model and the data is calculated on automatically selected points, which can be controlled using the “Select Regression Points” button.

Leave all the weights to 1. You may fix Pi by clicking on the corresponding checkbox.

Press Run

During the regression, a dialog shows the evolution of the parameters, and the successive iterations are shown on the history plot. When the regression completes, or if Cancel is pressed, the last solution is generated.

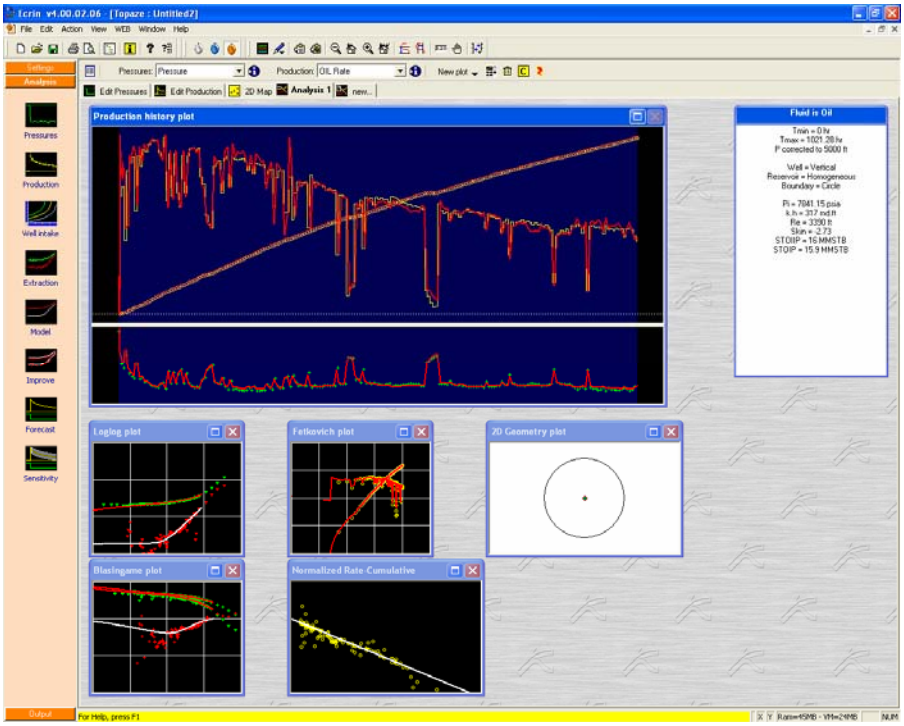


Fig C01.15 • Result after improve (loglog scale modified)

Final results can be seen for instance by double clicking on the status window (the window at the top right of the screen with the title “Fluid is Oil”).

D01 • Forecast

Select Forecast

In this menu it is possible to either extend the model, in terms of pressure or rate, adding to the existing history. It is also possible to create a new gauge, rate or pressure, using the existing model, or any other model.

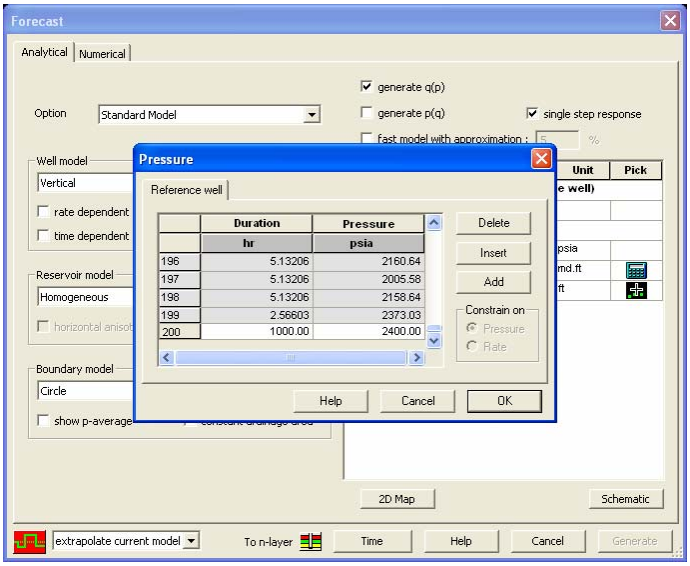


Fig D01.1 • Forecast

We will simulate rates from pressure, add extend the pressure history by 1000 hrs at a flowing pressure of 2400 psia.

Select  to enter the extension in the history, Fig D01.1.

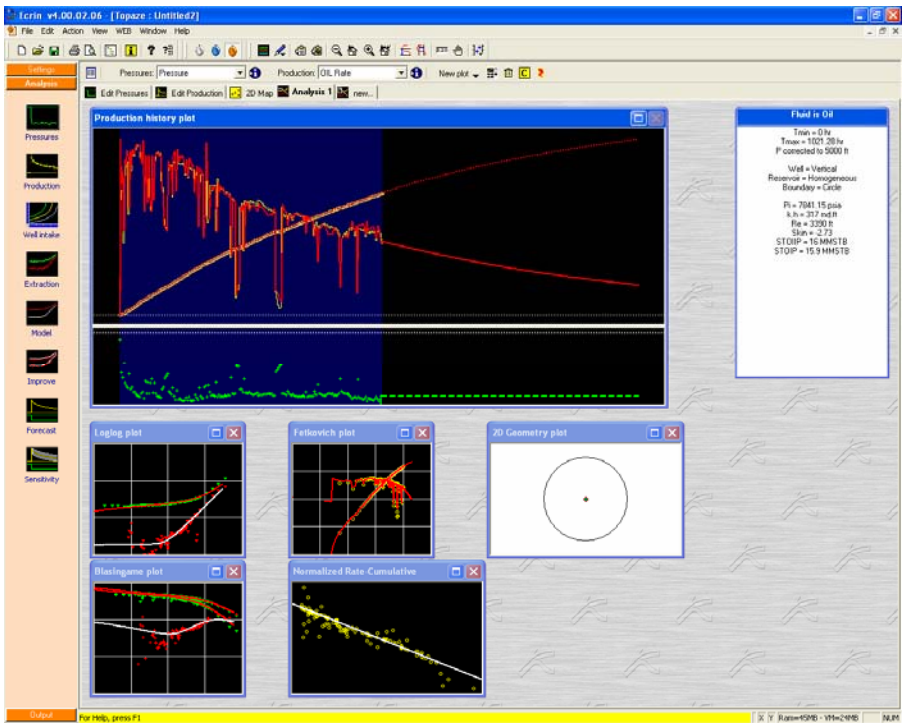


Fig D01.2 • Model extended for 1000 hrs at Pwf = 2400 psia

This concludes the interpretation of this data, with the current model. New analyses could be created in the same document using the 

icon, and results compared.

End of the this Guided Interpretation.