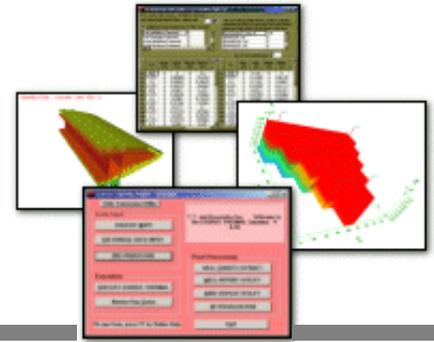


EXOTHERM

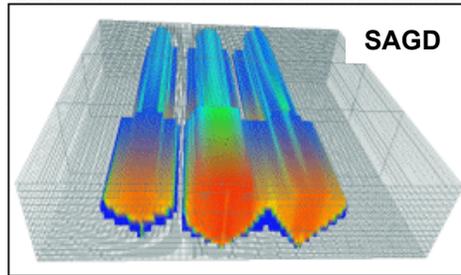
Thermal Reservoir Simulator for Microsoft Windows™

Designed for use with the Microsoft Windows XP™, and later, operating systems:

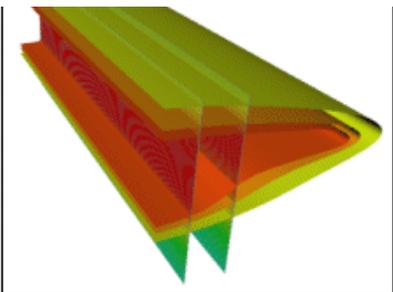


Simulator Features

- ▶ **Radial** and Cartesian Coordinates in 1, 2 and 3 dimensions. Local Grid Refinement.
- ▶ **Heat** transfer in reservoir and over/under burden
- ▶ **Fully** Implicit K-value compositional formulation. Any component can exist in any phase.
- ▶ **Dual** Porosity / Dual permeability for Naturally Fractured Reservoirs.
- ▶ **Arbitrary** Neighbour Connections.
- ▶ **Fast**, user independent, iterative sparse matrix solver.
- ▶ **Optional** Nine Point Transmissibilities.
- ▶ **Metric** or Field Units.
- ▶ **Days** or calendar dates.
- ▶ **Vertical**, inclined, or horizontal wells. Optional source/sink or discretized wellbores. Rigorous multiphase flow calculations, showing steam quality with time.

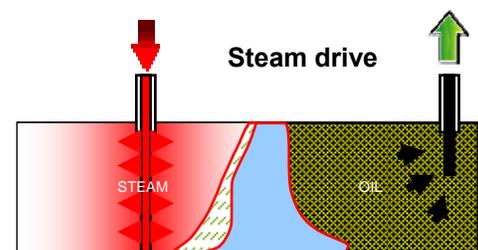
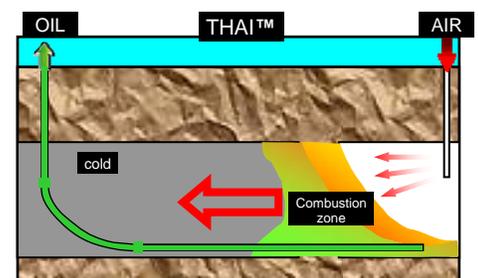


- ▶ **Multiple** relative permeability sets. Temperature dependent end points. Areally variable fluid contacts, critical and residual saturations. Relative permeability hysteresis.
- ▶ **Simultaneous** well constraints for oil, gas, water, liquid, and steam rates, flowing bottom hole pressure, fully coupled multiphase pressure loss correlations for horizontal wells.
- ▶ **Gathering** Centres for well grouping. Constraints for production, injection, steam-oil ratios.
- ▶ **Production** temperature reporting (mixed wellbore conditions)
- ▶ **Pressure** and temperature dependent porosities and transmissibilities
- ▶ **Geomechanical** properties; adsorption and diffusion considerations are optional.
- ▶ **Wormhole** modeling
- ▶ **Parallel** processing option with multi-CPU computers.



Simulator Applications

- ▶ **Thermal** recovery processes such as Steam Assisted Gravity Drainage, Cyclic steam stimulation, steamflood.
- ▶ **Combustion** processes with chemical reactions. Simulate fire floods and THAI™ process.
- ▶ **Full** Field, 3 dimensional simulation with multiple wells, pattern elements, or individual well performance predictions.
- ▶ **Horizontal** well appraisal.
- ▶ **Transient** discretized well bore simulations with multiphase pressure loss correlations. Wellbore design from well head to toe. Includes ability to model multiple tubing strings of varying length over time. Gas-lift, heat injection etc. all possible.



Ease of Use Features

► **Graphical** user interface. Point and click with mouse to select options from command buttons, drop down menus, and check boxes.

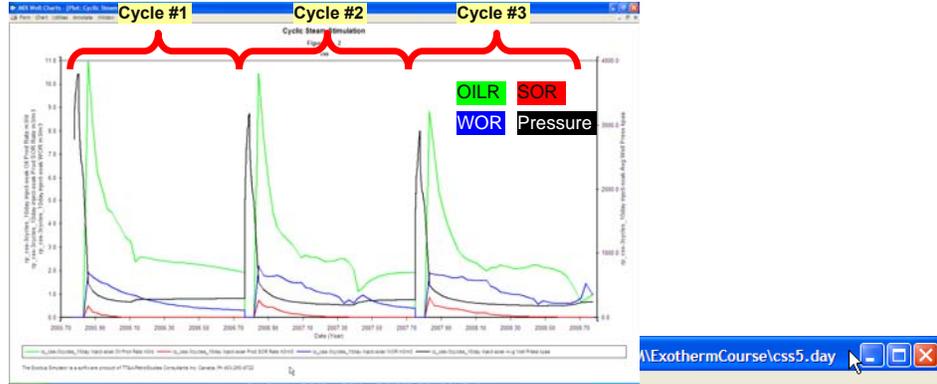
► **Full** on-line help. Obtain detailed description of menu items for each displayed form. Search Help file for topics or keywords.

► **Spreadsheet-type** data entry forms with inline data cell editing. Edit functions such as copy and paste, fill down, fill right, and undo.

► **Exchange** data with other Microsoft Windows™ applications. Cut and paste customized well summaries to wordprocessors for reports. Copy tabular data to spreadsheet programs for customized manipulation.

► **Run** the simulator in the background when other time critical tasks need to be done. Monitor flood fronts and performance of wells with post processing programs such as Grid Display, Well Charts and Well Report while the run is still processing. Stack up multiple cases to run at specific times for batch processing.

► **Output** to any Microsoft Windows™ supported printer or plotter (colour or b/w).



ExothermCourse\css5.day

All Components Base Pressure kPaa 101.4 Base Temperature oC 15.5

Component 1 Name WATER Write mole frac to .BLK

Molar distribution of Component in phase at Surface Conditions

Oil	0	Gas	0	Water	1	Molecular Weight	18.02
-----	---	-----	---	-------	---	------------------	-------

Stock Tank Density kg/m3 of Component in phase

Oil	0	Gas	0	Water	1000	Pc kPaa	22105
						Tc degK	647.2

Heat Capacity Coefficients kJ/kg/oK, .../oK^2, .../oK^3

0	0	0	Heat of Vaporization kJ/kg	0
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Phase Properties at Reservoir Conditions

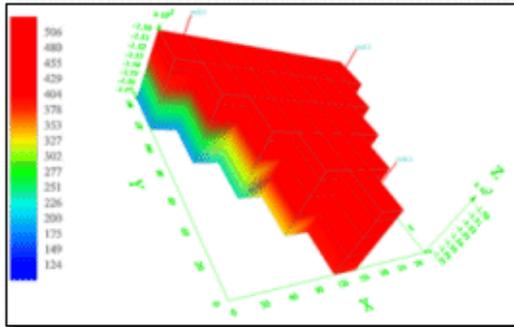
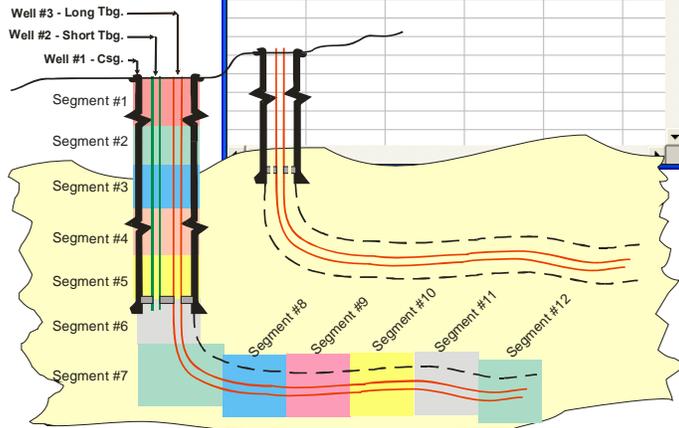
Component Properties in Phase - Select -> Water Oil Gas

WATER PHASE PROPERTIES

Base Density Kg/m3 1000 Compressibility Cp v/v/kPa 5.8E-07 Thermal Expansion v/v CT1 /oC 0.00072 CT2 /oC^2 7.30E-06

K values Correlation Tables Viscosity cp Correlation Tables

Temperature oC	(1) Pressure kpa	(2) Pressure kpa	(3) Pressure kpa	(4) Pressure kpa	(5) Pressure kpa	Temperature oC	Viscosity cp
Temperature	22105					15.6	1.13
647.2	1					23.9	0.94
						26.7	0.86
						37.8	0.69
						48.9	0.56
						65.6	0.43
						93.3	0.31
						121.1	0.23
						148.9	0.18
						204.4	0.15
						260	0.12



System Requirements

► **PC** with 2 Mb RAM for each 1000 grid cells. 200+ Mb HDD. Windows XP, Vista, "7"

Price

► **EXOTHERM** is priced based on the number of active grid cells. Purchase or lease the version that will fit your reservoir problems, and upgrade for the difference in price as needed.

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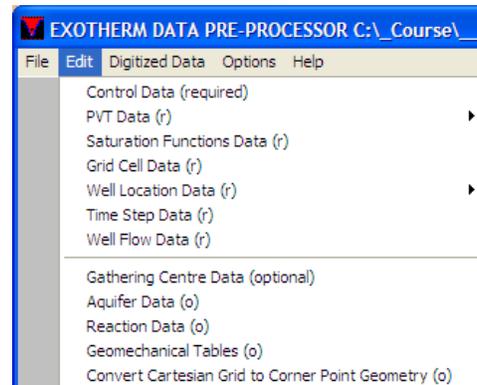
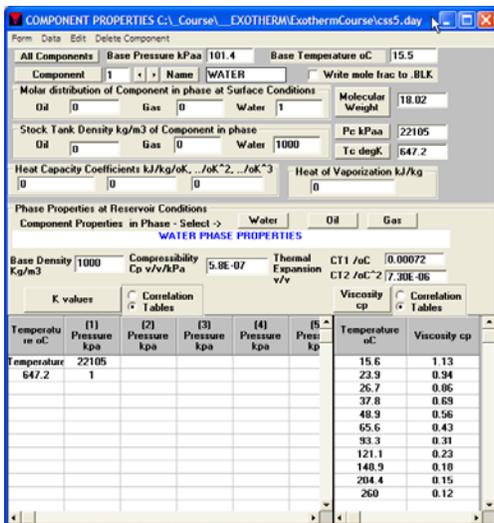
Exotherm Reservoir Simulator

Pre Processing Modules

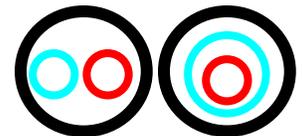
Quickly and effectively digitize map data, build simulation grids over maps, infill to get grid properties, import production and pressure history, build complete simulation data sets with comprehensive error checking, all with interactive, user friendly, graphical user interfaces.

PRE-PROCESSOR

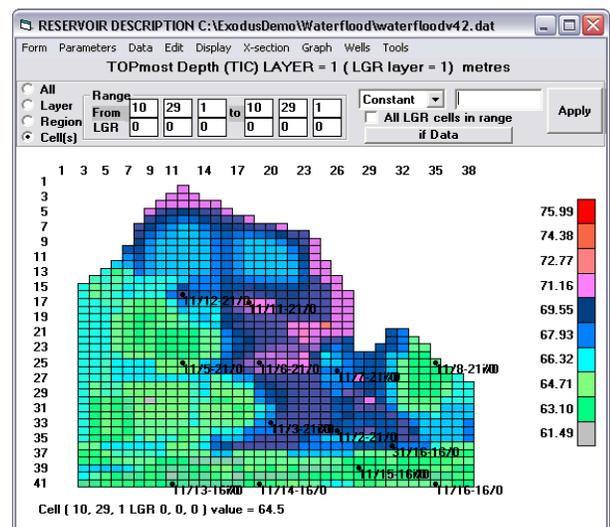
- ▶ A graphical interface to create, view and edit Data Sets with full Microsoft Windows features (menus, tabular entry, mouse control, data exchange) and comprehensive error checking.
- ▶ Display and modify tabular values in spreadsheet format.
- ▶ Correlations for relative permeability. Automatic normalization and de-normalization for scaling of end points.



- ▶ Automatically compute and modify non-neighbour fault connections and pinch-out transmissibilities.
- ▶ Locally refine grid cells with a couple of mouse clicks.
- ▶ Enter well production/injection data on a well by well basis (displayed all time data for a well or vice-versa).
- ▶ Import historical production values from commercial production history databases.
- ▶ Discretized wellbore with segmented definition for casing and multiple tubing strings which may be parallel, or concentric.
- ▶ Steam trap control option
- ▶ Pure energy injection possible
- ▶ Gas lift



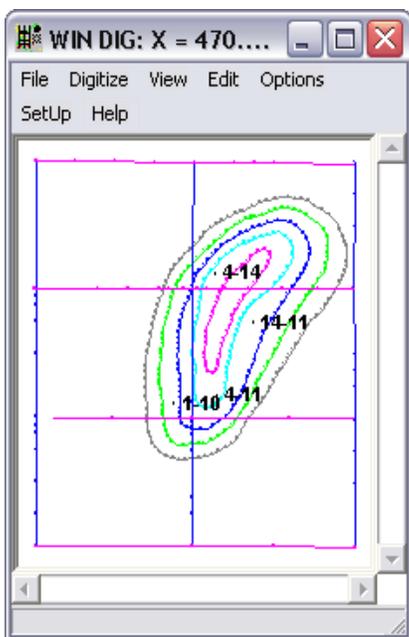
- ▶ Full Reaction Kinetics entry via stoichiometric coefficients, Arrhenius reaction rate constants, activation energy and heat of reaction for all equations needed to describe your problem.
- ▶ Interactively build grid over digitized maps. Rotate, stretch, move grid lines with mouse. Infill digitized layer maps to obtain grid cell values.
- ▶ Enter grid cell data directly or from digitized maps. Import digital maps from many other mapping programs.
- ▶ Modify grid cell values with edit functions (add, multiply, constant). Enter complex formulae to compute grid cell values from other grid cell values with conditional statements. Enter values by layer or as constant for all cells. Synchronized 2D and 3D displays
- ▶ Corner Point Geometry Grid. Display shape of cells.
- ▶ Obtain cell values from well point values, then infill non-well cells.
- ▶ Group cells into regions for editing operations (e.g. facies)
- ▶ Colour cells with user selected palette. Obtain shaded contours of grid cell values. Superimpose digitized maps. Display xy, xz, yz cross-sections.



Exotherm Pre Processing

WIN-DIG

- ▶ Digitize paper maps using a variety of digitizers, or digitize scanned bitmaps into the format for Exodus import.
- ▶ Transform digitized files from other mapping applications into the format for Exodus import.
- ▶ Interactively edit line contours or well points.



Historical Data Input

- ▶ Import Production History and Pressure History Data from external production history databases.
- ▶ Create User Defined History Data files for any time and any observation.
- ▶ Use Historical Data files for comparison against simulation results.
- ▶ Export production history to Preprocessor data file.

PROD/INJ DATA

Form Edit Options

Well Number: 1 Well Name: 00/08-27-087-19W6/0

Select wells from dropdown List

Enter injection rates as -ve numbers. Cumulative columns cannot be edited.

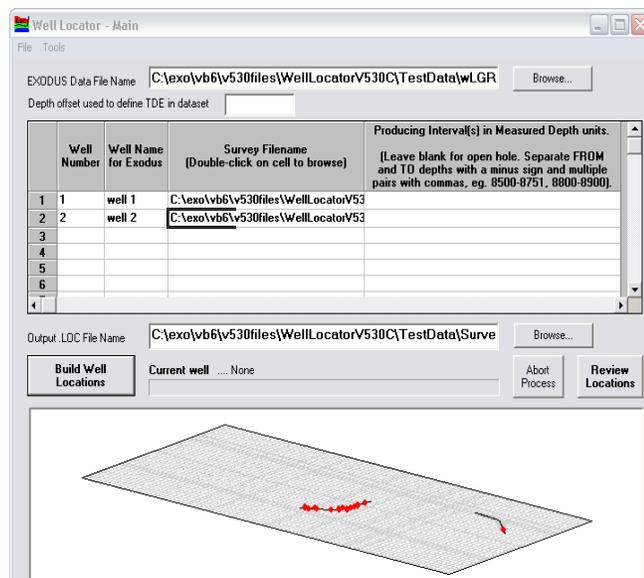
	Year	Month	Month Oil Prod m3	Month Gas Prod e3m3	Month Water Prod m3	Cum Oil m3	Cum Gas e3m3	Cum Water m3
1	1980	9	223.7	30.1	0	223.7	30.1	0
2	1980	10	185.6	16.8	0	409.3	46.9	0
3	1980	11	139.9	13.8	0	549.2	60.7	0
4	1980	12	161.6	19.7	0	710.8	80.4	0
5	1981	1	158.7	19.4	0	869.5	99.8	0
6	1981	2	178.2	18	0	1047.7	117.8	0
7	1981	3	157	15.6	0	1204.7	133.4	0
8	1981	4	106.3	8.7	0	1311	142.1	0
9	1981	5	153.7	15.8	0	1464.7	157.9	0
10	1981	6	147.8	15.3	0	1612.5	173.2	0

Well Deviation Survey to Well Locations

Identify well location cells from the trajectory of the well given the grid cell model and well coordinates or deviation survey.

The perforation fraction of the well locations will be computed using the open interval of the well and the length of wellbore in the cells.

Multiple wells can be batch processed.



Custom utilities to convert data files from other simulation software are available.

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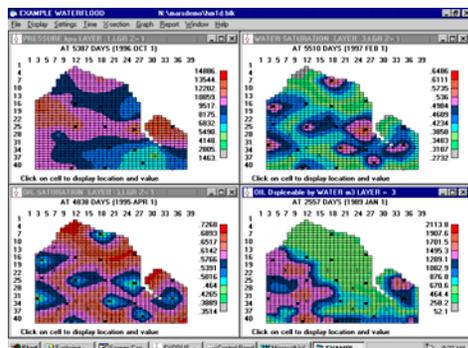
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Exotherm Reservoir Simulator

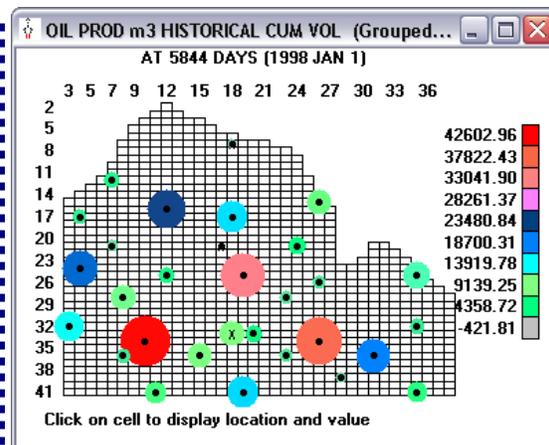
Post Processing Modules

Grid Display Utility



- ▶ During or after a run, display multiple windows of 2D colour maps of any grid cell values using automatic or user defined color palettes and value ranges.
- ▶ Show multiple cases, multiple views for different times/parameters and/or cross-sections (layers).
- ▶ Formulae to compute new display parameters for comparison of cases or difference in parameter values with time
- ▶ All these views can be manipulated, interrogated, printed or animated independently (user selectable time intervals) or synchronized.
- ▶ Display XY, XZ, YZ cross-sections. Define and show arbitrary cross-sections. Group layer values into single zone values for display.

- ▶ Simultaneously display a 3D view with 2D display. Interactively alter, rotate, zoom 3D view independently or synchronize animation with 2D view.
- ▶ Zoom/ Unzoom/ Pan option.
- ▶ Shaded contours of cell values.
- ▶ Display locally refined grid cell values. Cross-sections of locally refined cells.
- ▶ Display well locations and well names as a function of time.
- ▶ Superimpose digitized maps over computed grid cell values.
- ▶ Cell value enquiry, text values displayed in cells in selected font. Export all values to spreadsheet.
- ▶ Initial values of Porosity, Permeability, Depth, Thickness, Pore volumes.
- ▶ Time dependent values of pressure; oil, gas and water saturations; ternary phase saturations; volumes of fluids-in-place; displaceable volumes of oil.
- ▶ Define arbitrary regions before, or after, a run and display oil-in-place, average pressure, production rates and cumulatives, migration and percent recovery.



- ▶ Bubble maps for historical data or calculated discrepancies. Animate bubble maps with time.
- ▶ Graph cross-section values or cell values with time.
- ▶ Display well charts simultaneously of selected wells with 2D views.
- ▶ Display detailed migration statistics for user defined regions built either before or after the run. Interactively select reporting regions.
- ▶ Debugging aids to assist in identifying regions with convergence problems and to show where changes are needed in subsequent history matching runs.

Well Report Utility

- ▶ Customize well summary reports from simulation runs.
- ▶ Choose from over 40 report parameters.
- ▶ User defined units for any report parameter.
- ▶ Create and save user defined tabular format.
- ▶ Interactively define groups of wells and well fraction
- ▶ Report by well/group/field for all times and parameters.
- ▶ Report at any time for any or all wells and parameters (by completion cell if desired).
- ▶ Report for selected parameters, all wells/groups and all times.
- ▶ Report at any time for any or all wells and parameters (by completion cell if desired).

- ▶ Immediately graph current report. User definable placement of series on axes.
- ▶ Summaries for groups of wells, and field. Print or copy and paste report to a spreadsheet or word processor.

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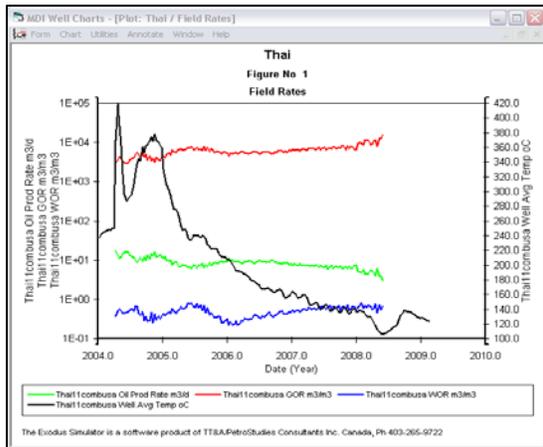
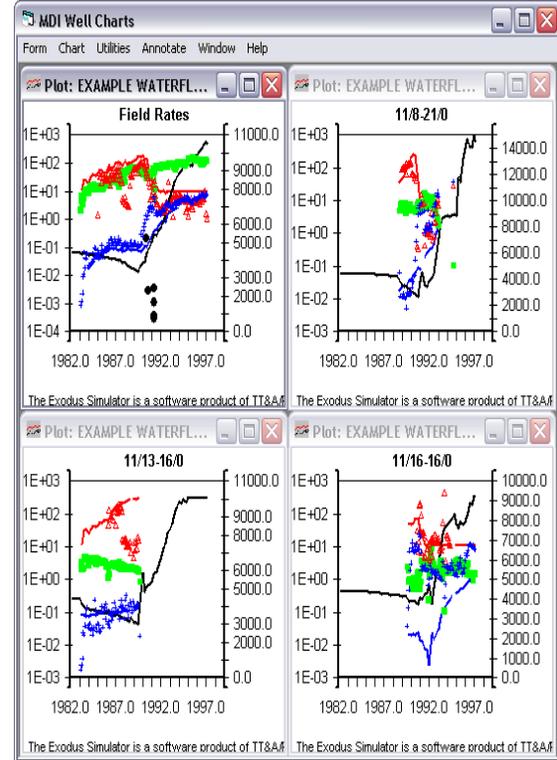
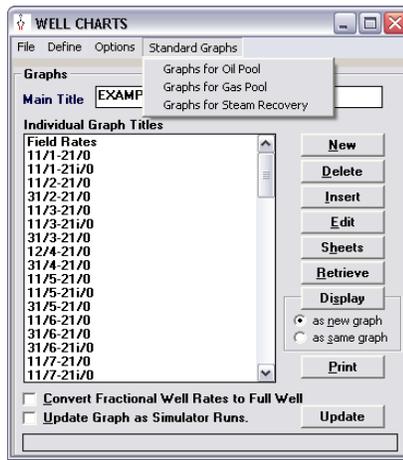
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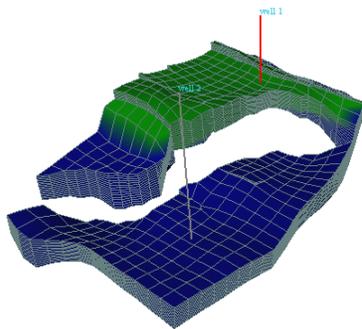
Well Charts

- ▶ Produces graphs of well performance from simulation cases, production history data and pressure history. Automatic update as simulator executes in background.
- ▶ Quickly generate graphs from standard default graph types.
- ▶ Select from over 40 series options such as rates, ratios, cumulatives, well pressures, % recoveries etc.
- ▶ User defined units for any series.
- ▶ Compare simulated with historical values. Compare many wells on the same graph. Compare several runs on one graph. Group wells to create a graph series.
- ▶ Plot any series on X, left Y and right Y axes with appropriate scaling. Plot as many as 30 series on a graph.

- ▶ Annotate, change fonts, log or linear scales, automatic or custom linestyles and colours, tick marks, grid lines.
- ▶ Use the template facility to build graphs for all wells from one well graph.
- ▶ Multiple child windows of chart displays.



3 Dimensional Visualization



- ▶ Display 3-D views of the reservoir for parameters (e.g. porosity, permeability) and time dependent values of pressure, fluid saturations, fluid volumes in place.
- ▶ Pan, rotate, zoom the 3-D views. Show multiple cross-sections and isosurfaces. Interrogate cell values.
- ▶ Clip layers, rows and columns.
- ▶ "See" your reservoir produce. Start, stop and resume animation of all the views. Show well locations as they are drilled. Make cells visible only if they are in a specified data range and animate with time. Useful for water coning, front tracking, tracer animation etc.
- ▶ Alter the 3-D view by cutouts, shifting, spreading out or separating layers or cross-sections. Apply clipping or change the visible range of layers or cross-sections.
- ▶ Print or export image to bitmap files for import to other graphical programs.