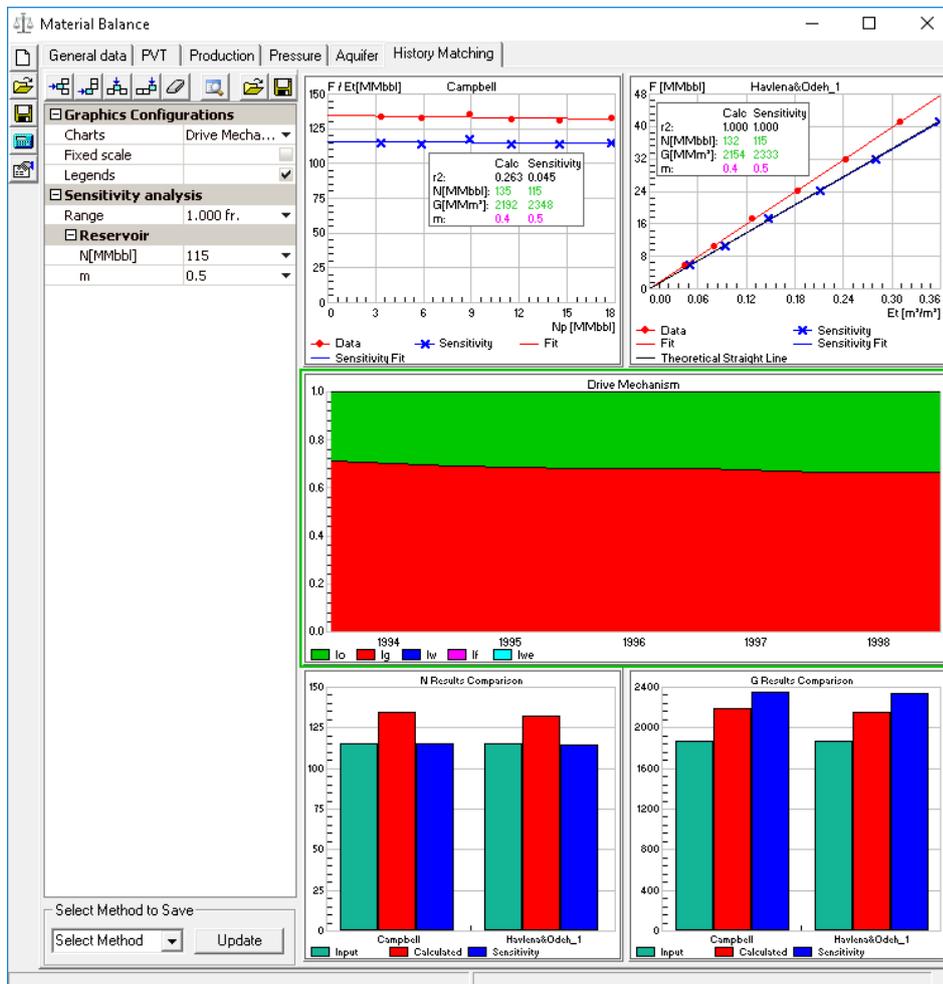


MATERIAL BALANCE

Material Balance is used as a method to estimate the original volume of hydrocarbons in the reservoir. The equation takes into account the various mechanisms that intervene during production and allows calculating the impact of each one of them.

Sahara's Material Balance tool helps perform an adjustment of historical production data for black oil, dry gas, wet gas and gas condensate reservoirs. It also offers different methods that, depending on the input data, can estimate hydrocarbons in situ.

In order to apply the material balance equation, it is required to have information about the PVT properties of the fluids involved. The Sahara PVT module helps obtain the necessary parameters from correlations and experimental PVTs or through compositional simulations.



A very simple and friendly interface allows performing a material balance quickly, validating the volumes of hydrocarbons in the reservoir.

Sahara

The Material Balance module helps perform history matches of a reservoir production data and estimate hydrocarbons in situ for black oil, dry gas, wet gas or gas condensate reservoirs. There are different calculation methods that can be chosen depending on the type of fluid studied and the input data that is available for analysis.

Before solving the material balance general equation, it is necessary to have PVT tables characterizing the different fluids within the pressure domain in which the analysis will be made. For this purpose, PVT data can be used for each fluid separately or just one set encompassing all of them. If data is available, it can be loaded in a table format to the PVT module and then used from the Material Balance window. If, on the contrary, data is not available, the PVT module can also be used to generate it using correlations.

Reservoir pressure and temperature data are also required, as well as some petrophysical information. There is also the option to load estimated data of fluid volumes, thus enabling additional calculation methods. Finally, production rates and pressure data over time must be available.

As mentioned above, the module has different methods that adapt to each type of fluid, and the results obtained with each of them can be analyzed and compared through a dynamic interface. The History Matching tab has a set of charts that can be selected and customized to perform the analysis. Availability of these charts depends on the type of fluid being studied and the input data loaded into the model. Among the charts available are the following:

Oil

- Campbell
- Havlena & Odeh, no gas cap, no aquifer
- Havlena & Odeh, known m or G, no aquifer
- Havlena & Odeh, unknown N and m, no aquifer
- Havlena & Odeh, with water influx

Gas

- Cole
- P/Z Method
- Samaniego
- Havlena & Odeh

Gas Condensate

- P/Z Method

Each of these charts can be used to make an adjustment by selecting the desired points. The results of the regression using the selected points will be reported in a box on the chart. In addition to the charts that allow evaluating each of the methods, there are other general charts, such as bar charts to compare the results obtained with the different methods and their relative differences, pressure vs. time or cumulative production display charts; and finally a particular one that is used to observe the conjunction of the drive mechanisms present and which is the predominant one.

General Charts Available for all Types of Fluid

- Drive mechanisms in a chart showing the relative drives
- Display of pressure and production vs. time; pressure vs. time and pressure vs. cumulative production
- Comparison of results of the different parameters

Additionally, Sahara allows performing a sensitivity analysis on any of the charts for each of the methods. The analysis is done using sliders to vary the values of the input parameters (S_{wi} , c_r , c_w , N , m or G) in order to get the correct result. When the sensitivity sliders are applied to these charts, the material balance equation is solved iteratively to obtain the pressure as the unknown variable. Correct values of N , m or G and W_e will provide a precise adjustment on the pressure data previously loaded. When performing a sensitivity analysis, blue crosses overlap the calculated red points in the charts. If a previous adjustment has been made for a chart, moving the sensitivity sliders will display a column with the results corresponding to the sensitivity analysis in the regression result box.

The user will be able to select one of the methods used to perform the balance to save the results of the analysis, which may be accessed later.

The Material Balance module allows using different methods to perform the analysis, comparing the results obtained with each of them and saving those results that provide the best fit.

Material Balance

General data | PVT | Production | Pressure | Aquifer | History Matching

General

Type of Fluid: Black Oil

Gas Cap:

Water influx:

Inject Fluid

Water:

Gas:

Reservoir Data

Initial Static Pressure: 3330.0 PSia

Temperature: 200.0 °F

Connate Water Data

Swi: 0.000 fr.

Cw: 0.00e+00 1/(kg/cm²)

Rock Data

Cr: 0.00e+00 1/(kg/cm²)

Fluids Data

N: 115 MMbbl

Enter: m

m: 0.4 ul

PVT

Pressure Domain: Oil, Gas and Water PVT

Load Oil, Gas and Water PVT: Loaded

Material Balance

General data | PVT | Production | Pressure | Aquifer | History Matching

Oil, Gas and Water PVT

Pb [kg/cm²]: 104.8

Pressure [kg/cm ²]	Oil Parameters		Gas Parameters		Water Parameters	
	Rso [m ³ /m ³]	Bo [m ³ /m ³]	Z	Bg [m ³ /m ³]	Bw [m ³ /m ³]	Bw [m ³ /m ³]
0.0	0.0	1.0214	0.9900	1.07490		
15.6	19.7	1.0925	0.9500	0.06320		
30.5	29.3	1.1142	0.9260	0.03170		
45.2	37.7	1.1316	0.9050	0.02090		
60.1	46.0	1.1481	0.8870	0.01540		
74.8	54.3	1.1640	0.8730	0.01220		

Material Balance

General data | PVT | Production | Pressure | Aquifer | History Matching

Cumulatives

Date	Np	Gp	w/p
1/1/1993	0	0	
1/1/1994	3.295	3459.8	
1/1/1995	5.903	6257.2	
1/1/1996	8.852	10268.3	
1/1/1997	11.503	14206.2	
1/1/1998	14.513	18358.9	
1/1/1999	17.73	23049	

Material Balance

General data | PVT | Production | Pressure | Aquifer | History Matching

Date	Pressure	nominal Point
1/1/1993	3330	<input type="checkbox"/>
1/1/1994	3150	<input type="checkbox"/>
1/1/1995	3000	<input type="checkbox"/>
1/1/1996	2850	<input type="checkbox"/>
1/1/1997	2700	<input type="checkbox"/>

Material Balance

General data | PVT | Production | Pressure | Aquifer | History Matching

Graphics Configurations

Charts: Pres/Prod vs t

Fixed scale:

Legends:

Sensitivity analysis

Range: 1.0000 fr.

Reservoir

N [MMbbl]: 115

m: 0.5

Campbell

Havlena/Odeh, 1

Havlena/Odeh, 2

N Results Comparison

m Results Comparison

Pres/Prod vs t

Pressure vs Time

Drive Mechanism

Material Balance. All the window tabs are displayed, from the initial data load, the display of the PVT parameters, the display of production and pressure data over time; and finally, the History Matching tab where a custom set of charts can be configured based on the desired analysis.

If water influx is evidenced in the case under study, the module provides the possibility of choosing among different aquifer models for different geometries and boundary conditions with the purpose of estimating the size of the aquifer involved:

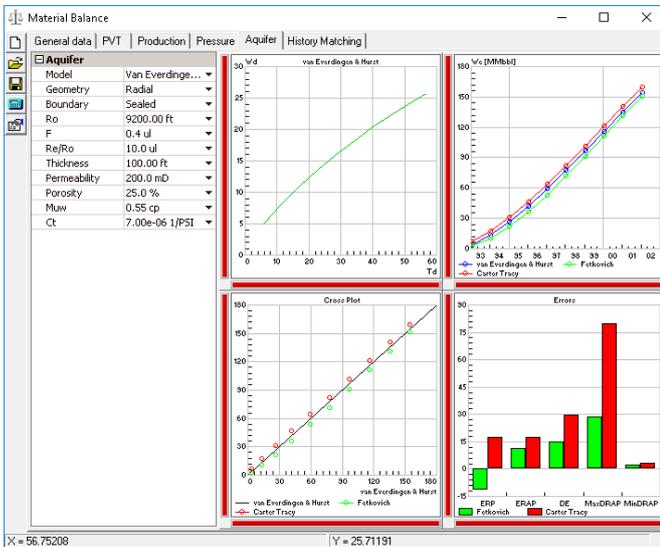
Models of Aquifers

- van Everdingen & Hurst (1949)
- Carter & Tracy (1960)
- Fetkovich (1961)
- Schilthuis (1936)
- Pot

Geometries

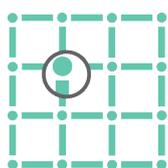
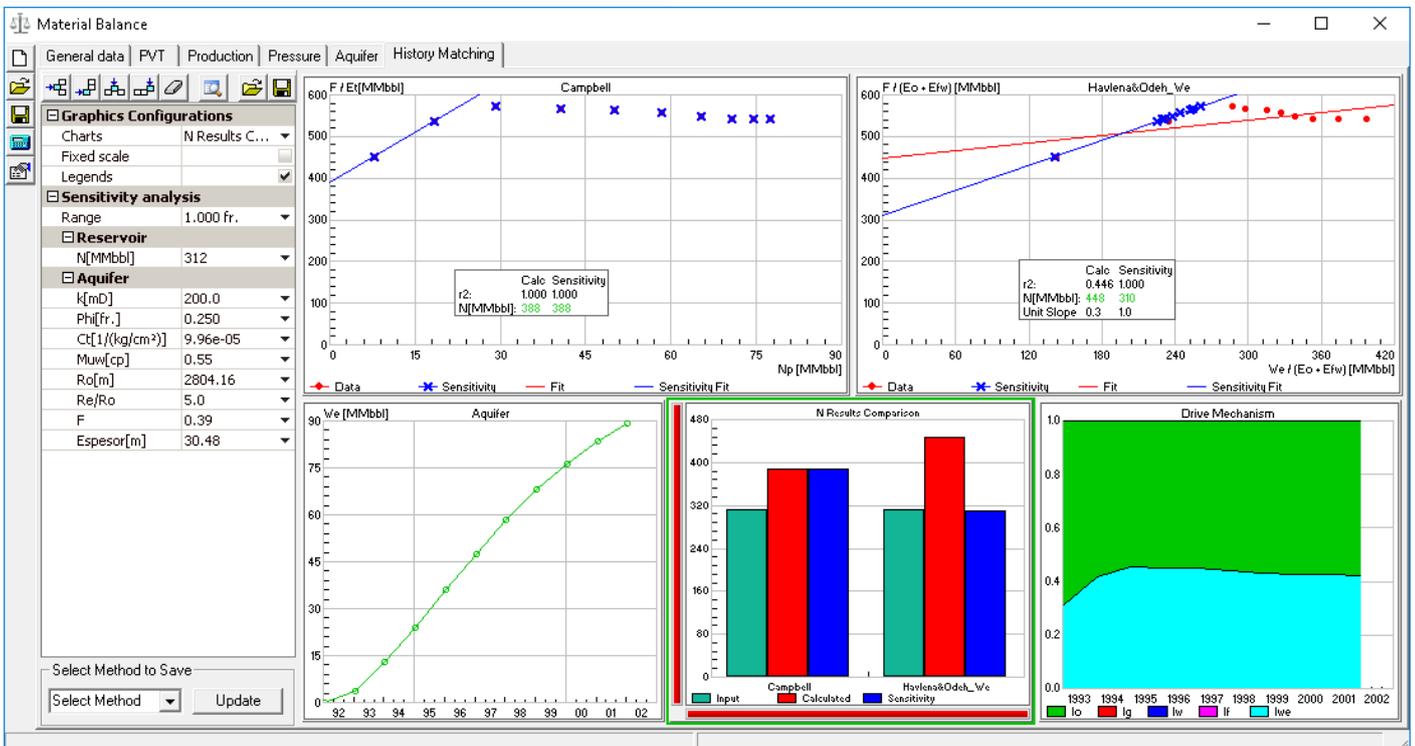
- Radial
- Linear

In this Aquifer section it is possible to make a comparative study of the different methods available, for a given geometry and boundary condition. The geometry and boundary options, needed to perform the calculation, can be defined depending on the model chosen.



Aquifer Tab. Picture shows the analysis and comparison of the different methods available for the calculation of aquifers of radial geometry with a sealed boundary, which are van Everdingen & Hurst, Carter & Tracy and Fetkovich.

History Matching Tab. Picture displays a material balance analysis in which the predominant drive mechanisms are the expansion of oil and aquifer drive.



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