PVT for Unconventional Reservoirs

Summary

Understanding the PVT properties of unconventional reservoir hydrocarbons are critical for predicting well performance. This example outlines two considerations when developing reservoir simulation inputs from experimental PVT data.

Development of PVT inputs for Reservoir Simulation

Liquid-rich unconventional reservoirs typically contain volatile oils or near-critical retrograde condensates. In both of these cases, the reservoir gas phase contains condensate that contributes significantly to oil production and therefore cannot be well characterized by a traditional black oil PVT model. In addition, the standard PVT experiments for volatile oils and retrograde condensates do not provide the data necessary to develop a PVT dataset for a modified black oil reservoir simulator that allows free gas to carry condensate.

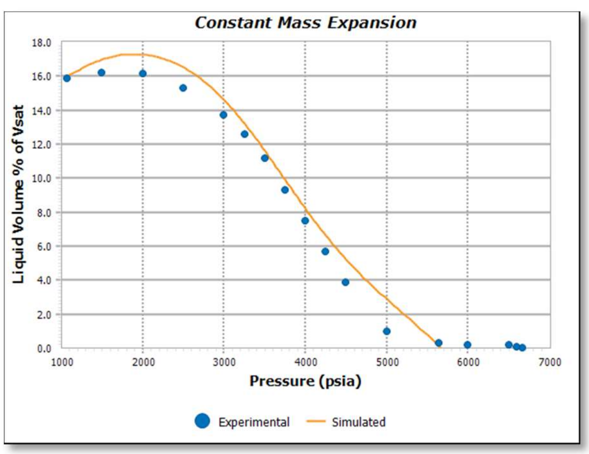

Figure 1: Experimental volume expansion data with the fitted equation of state.

Correlations are also not available for these fluids.

To generate the needed properties for reservoir simulators, an equation-of-state fluid characterization is required. This characterization is developed through regression of PVT data. Once the equation-of-state fluid characterization that matches the measured data is established, a modified black oil table that includes the condensate in the gas phase can be generated. This black oil table is the input parameter for the reservoir simulator. Figures 1 and 2 are examples of fitting experimental data to the equation of state. Table 1 is an example PVT black oil table developed for reservoir simulation with unconventional reservoir fluids.

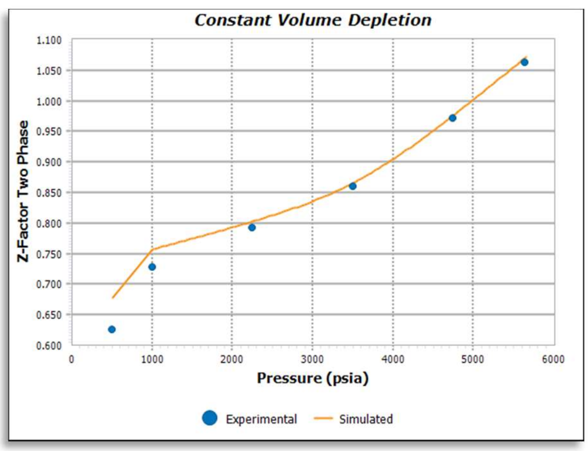

Figure 2: Two-factor Z-factor experimental data and the fitted equation of state

Many reservoir simulators do not have appropriate equations of state for the light oils and retrograde condensates associated with unconventional reservoirs. Converting experimental PVT data into a black oil table becomes necessary.

PSAT	BO	RS	VISO	rs2	BG	VISG
psia	*rb/stb*	*scf/stb*	*cp*	*stb/mmcf*	*rb/scf*	*cp*
2000	1.313	422.0	0.43	17.0	0.001627	0.021
2500	1.381	552.0	0.38	22.0	0.001301	0.024
3000	1.452	691.0	0.33	29.0	0.001094	0.027
3500	1.526	842.0	0.30	37.0	0.000956	0.031
4000	1.605	1004.0	0.27	47.0	0.000858	0.035
4500	1.688	1178.0	0.24	58.0	0.000789	0.039
5000	1.771	1356.0	0.23	71.0	0.000738	0.044
5500	1.846	1528.0	0.22	84.0	0.000701	0.049
6000	1.910	1685.0	0.22	96.0	0.000674	0.055
6500	1.967	1834.0	0.22	108.0	0.000653	0.061
7000	2.026	1988.0	0.22	119.0	0.000638	0.061

Table 1: Example of a PVT black oil table for simulation of an unconventional reservoir. Many reservoir simulators do not have equations of state for the light oils and retrograde condensates associated with unconventional reservoirs.

Extrapolation to In-Situ Fluid Compositions

Because of their low permeability, many times unconventional reservoirs are sampled at flowing bottom hole pressures well below their saturation pressure. In this case, the produced fluid can be the result of two-phase flow and is not representative of the in-situ reservoir fluid. Because of the long periods of non-boundary dominated flow in unconventional reservoirs, the gas-oil ratio may stay constant, which may be mis-interpreted as indicating the sample was taken above the saturation pressure.

An equation-of-state can be used to extrapolate back to an original in-situ fluid composition based on measured data from a PVT study on a non-representative sample and well production history; this concept is outlined in Figure 4.

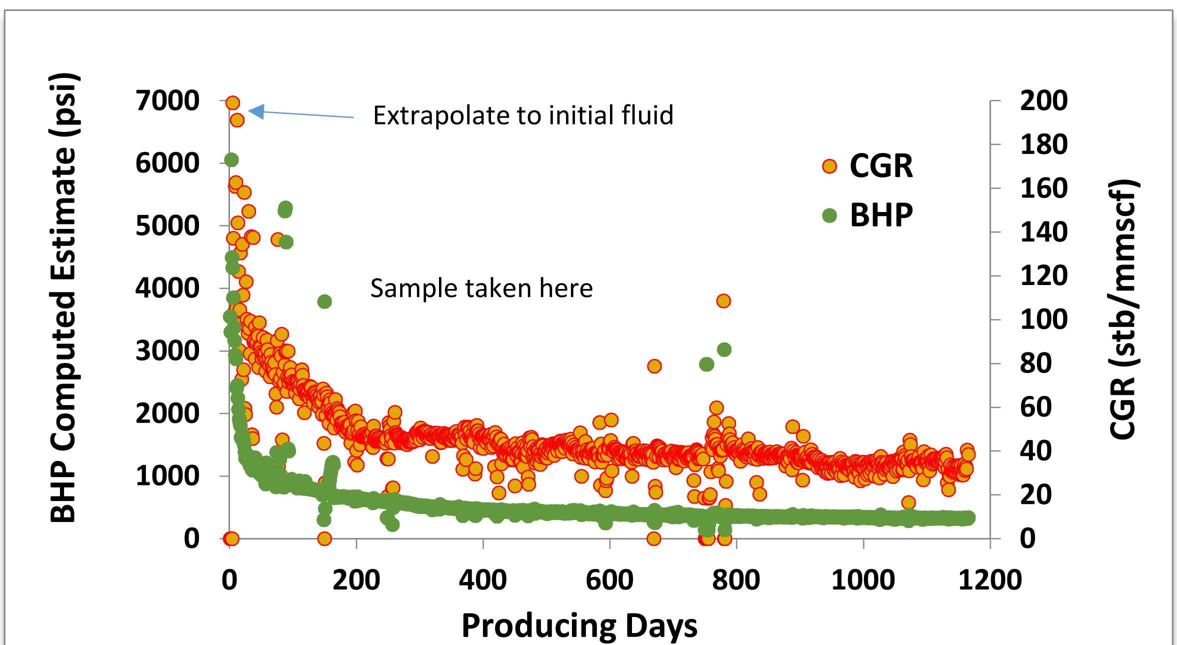

Figure 3: Extrapolating PVT data to the original in-situ fluid composition using an equation of state.