Application of the modified Yen model for reservoir evaluation and exploitation

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The modified Yen model was recently proposed and stipulates the molecular and colloidal structure of asphaltenes in crude oils.[1] Specifically, the model consists of molecules of somewhat modest size, nanoaggregates consisting of ~6 molecules and clusters consisting of ~7 nanoaggregates as shown in Figure 1.

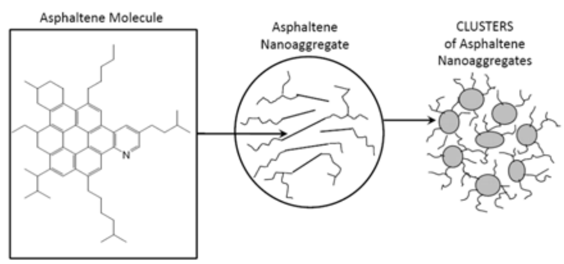

Fig. 1. The molecular and colloidal components of the modified Yen model.

This model is consistent with many diverse laboratory studies. In addition, the modified Yen model has found important applications for characterization of oil reservoirs. In particular, for the first time, this model has enabled the characterization of asphaltene (and viscosity) gradients in oil reservoirs from a first principles approach. Consequently, new protocols for evaluating reservoir compartmentalization and connectivity have been developed and have proven correct in production. In addition, a broader understanding associated with asphaltene gradients and asphaltene phase behavior is being developed impacting Flow Assurance. Various case studies are shown with explicit relation to the modified Yen model. The close agreement between field and laboratory studies is striking.

In a specific multiwall case study, a single reservoir was penetrated by several wells. The reservoir was known to have two separate gas caps from seismic surveys. In spite of this, the reservoir has been viewed as a single sand. A problem arose when the two separate gas-oil contacts were found to differ by 20 meters true vertical depth. The implication is that either the reservoir is compartmentalized with (equilibrated) fluids in each compartment, each with its own gas cap or the reservoir fluid has a subtle lateral disequilibrium and is one compartment. The heavy ends do not partition at all to the gas phase and are largely unaffected by the multiple gas caps.

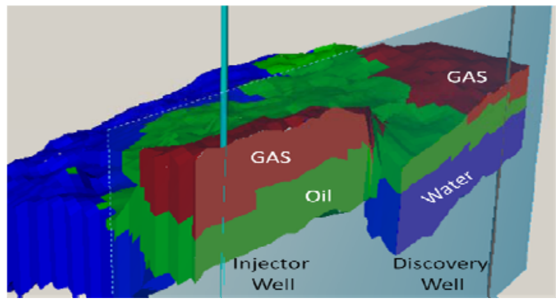

Fig. 2. Subsurface reservoir horizons showing two gas caps in local maxima, oil and acquifer. The key question is whether the oil bearing sand is laterally connected across the reservoir. If so, the field development plan with the label “injector” is valid. If not, the FDP must be dramatically changed.

Figure 3 shows that for the most part (but not entirely) the heavy ends grade in concentration continuously across the reservoir. The outlier points (too much heavy ends) are near the respective oil-water contacts where other processes may contribute to heavy end concentration or distribution.

Based on the heavy end distribution, the prediction of connectivity is made. Production of the field has proven this prediction to be correct.

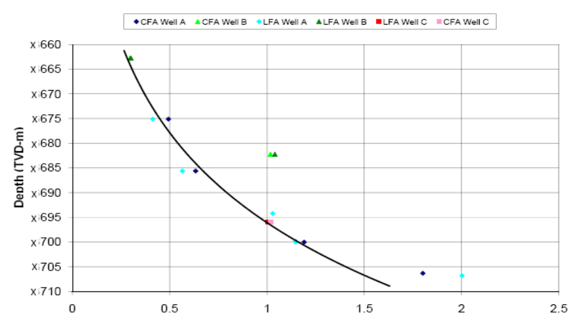

Fig. 2. Multiwell data showing asphaltene gradients across a reservoir. Most, but not all data fits an equilibrium molecular dispersion of asphaltenes. Given low diffusion rates of asphaltenes, this data supports the reservoir rbeing connected.

The tremendous utility of this new approach to address the biggest concerns in reservoirs portends a far broader scope for asphaltene science.

References

[1] Mullins, O.C., The modified Yen model, Energy & Fuels, in press