Bridging the Gap Between Petroleum Systems Modelling and Prospect Assessment – How to Consistently Predict Hydrocarbon Phase and Column Height

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Abstract

Traps containing both oil and gas, or dual phase accumulations, are very frequent in many hydrocarbon provinces but generally poorly treated in prospect assessment. The possible presence of gas, competing with oil for pore space and seal capacity, complicates exploration decisions in many areas.

Petroleum systems modelling (PSM) allows for the testing and quantification of geological scenarios with respect to hydrocarbon charge, its timing and composition. It is however limited when it comes to the prediction of the retained phase (oil or gas or both) and the associated column heights. This is due to intrinsic issues such as input data resolution and model grid size, but also because of the deterministic nature of the modeling while using parameters which are highly uncertain.

On the other side, prospect assessment is highly probabilistic, covering a large range of possible outcomes using Monte Carlo simulations. Standard prospect assessments however do not receive any quantitative input from PSM. In most cases, qualitative recommendations such as “high risk for gas” or “small column heights are not excluded” are given, based on a suite of deterministic models.

We present a workflow where PSM and prospect assessment are combined in a quantitative way. In our workflow we make assumptions about pressure and temperature conditions, the initial charge composition, as well as charge and seal conditions. These input assumptions come from PSM end-member models such as minimum charge mass, pressure and temperature gradients, or compaction-derived seal properties. Uncertainty distributions are assigned to fill in the gaps between these end-member input assumptions.

Monte Carlo simulations provide quantitative estimates of charge volume with in-situ phase and densities, which are balanced with prospect-specific seal limitations (top and lateral seal integrity and capacity limits) in a dual phase system. This allows us to predict liquid versus vapor column heights, leak and spill occurrence, and associated properties such as PVT-derived gas-oil ratios and formation volume factors, and ultimately in-place and recoverable resources.

In the presented paper, we discuss:
(1) The general issues of PSM when it comes to prospect-scale predictions,
(2) The sensitivity of column height and oil versus gas phase on seal and PVT assumptions,
(3) The estimation of the chance of success for oil versus gas (COS, or “risk”),

(4) The composition of success-case volumes (“resources”),
(5) Oil versus gas column heights, and
(6) The consistent assessment of prospect versus well COS in the likely presence of two phases.