Pre- and Post-well Predictions of Oil and Gas Columns Using an Iterative Monte Carlo Technique with 3D Petroleum Systems Modelling

Are Tømmerås[1], Matthias Daszinnies[1], Davide Mencaroni[1], and Øyvind Sylta[1]

[1]Migris AS

ABSTRACT

Monte Carlo simulation techniques can be used to study complex processes because the technique can relatively easily be implemented using random number generators in combination with deterministic models. In this paper we discuss how the Monte Carlo simulation techniques can be applied for the calibration of a 3D petroleum charge model, making predictions for undrilled prospects, and also for post-drill analyses. A labor intensive and subjective calibration process can be partly replaced by a more objective (and more testable) approach, and this has the potential of leading to more reliable predictions of hydrocarbon resources in undrilled areas.

The result of the iterative procedure outlined in this study is a stochastically calibrated petroleum systems model. The stochastic model will contain many realizations that are good (low misfits) at explaining the observations and some that are very good at matching the calibration points. Therefore, we can use the "best" N simulation runs to estimate probability histograms or probability maps of the model output parameters. N is typically chosen to be between 500 and 1000, depending on how large the modelled errors (misfits) are. Larger misfits are an indication that more runs will be needed to obtain acceptable estimates.

Frequency diagrams of the oil and/or gas column heights at specific locations can be compiled from the calibrated stochastic model. This means that probabilities of oil and gas columns can be extracted as e.g. P90, P50 and P10 (a P10 oil column of 50 means that there is a 10% probability that the oil column is greater than 50m). Here, there is a 42% probability that the oil column is 0m (dry well) while the P50 is 25m and the P90 is 31m oil column. This type of figure can be extracted from a stochastically calibrated basin model at any future well location and therefore provides a direct prediction of the oil columns at that location, together with the uncertainties of these predictions. The assessment can be done either in a qualitative or quantitative manner. The assessment may be useful for single well post-drill analysis, but it is even more interesting when more wells have been drilled. Already, after a few wells have been drilled in the area, a probabilistic measure of the quality of the predictions can be established. For each drilled well the cumulative oil column frequency diagram can be used to extract the Y value (model probability) of the drilled column height.

The outlined methodology can be used to quantify charge (source) risk factors in the exploration for oil and gas. The method links uncertainty estimates of source, reservoir and seal properties to modelled oil and gas column heights and their uncertainties. The most important characteristic of the methodology is, however, that it can easily be used to objectively test drilling results from new exploration wells.