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Transition Zone Reservoir Box Modelling

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Abstract

This piece of work illustrates the use of a simple box-modelling approach to simulate the so-called pancake reservoirs (thin reservoirs within a transition zone) for an infill development project. The objective of this work is to locate the remaining oil between existing No Further Activity (NFA) wells which are at 60m spacing and quantify opportunities to drill new infill wells at denser 30m spacing. A simple layer-cake box model is constructed such that it contains key input data to mimic the observed transition zone within the reservoir. The process involves simplified process of data gathering and QA/QC, model initialization, History Matching and Forecasting as well as Uncertainty Analysis.

Part of the data gathering, and QA/QC is understanding the existing actual patterns of configuration (i.e. Producer-Producer-Injector PPI patterns), rock and fluid properties and capillary curves and relative permeability curves. The constructed models contain two km long Producer-Producer-Injector (PPI) patterns at 60m lateral spacing and ~15m vertical spacing between producers and injectors. Capillary pressure curves for two dominating rock facies are used that best represent the oil saturation in the transition zone observed in the field based on porosity binning for each rock facies.

Initialization of the model focused on replicating the necessary actual data into the model such as rock facies, porosity, Pc curves and the depth of Free Water Level (FWL) that result in oil saturation in line with the actual transition zone observed from the well logs. Due to the uncertainty in the depth of FWL, it was used as one of the key variables for adjustment to get the appropriate oil saturation across the reservoir.

History Matching process focused on matching pressure, Productivity Index (PI) of the OPs, Injectivity Index (II) of the WIs and Recovery Factor vs Injected Hydrocarbon Pore Volume (RF vs HCPVinj). This was achieved through constraining the liquid offtake from the OPs, injection rate in the WIs, and flowing bottom hole pressure of the WIs such that they do not exceed fracture pressure.

After the history matching, the model can forecast the 60m spacing NFA wells in line with the actual wells' performance. It is also clearly showing the conning effect around the OPs leaving behind some unwept oil between NFA wells. Furthermore, the model can forecast the denser 30m infill wells with reasonable match compared with the actual 30m infill wells drilled in the field. Due to variation in actual horizontal well lengths in the field, and since the model contains 2km long horizontal wells, the comparison between model and actual was done through normalizing wells performance per 1km of open hole length.

The model is a useful tool to answer a key question which is whether, or not, denser infill drilling at 30m spacing is adding any incremental oil or just accelerating oil production that NFA can produce over time. In this case, the model shows that the 30m infill wells are producing oil that is both accelerated oil as well as incremental/untapped oil pockets that are not swept due to conning effect around the producers. This check was done through comparing the difference in ultimate recovery between a model with 30m infills and a model without 30m infill wells. Moreover, to quantify the accelerated oil production, sensitivity analysis was done on the model with the 30m infill wells by introducing the infills at different times. The results show the earlier the infill wells are drilled the higher the accelerated oil production from the infill well. This is useful to filter out patterns that are mature enough in Recovery Factor and HCPVinj such that introducing denser infill drilling is economically not attractive.