Honoring the Depositional, Diagenetic, and Tectonic History in a 3-D Computational Model of a Carbonate Reservoir: Charles Fm., S.E. Saskatchewan.

Garrett K. Timmerman, Enerplus, Calgary, AB

Introduction

A reservoir model has been constructed for three pools currently undergoing a development plan that includes waterflood support from existing vertical and horizontal wells and infill drilling with multi-lateral horizontal wells. The Freda Lake, Skinner Lake, and Neptune pools produce from the lower Ratcliffe member (Oungre Beds) of the Mississippian Charles Formation in the north-central Williston Basin. The producing interval consists of inter-fingered limestone, dolomite, and anhydrite with stratigraphic trapping due to lateral facies changes and an overlying evaporite. In order to build a representative model the depositional, diagenetic, and tectonic factors that influence the reservoir have been considered as independent elements and then combined in a sequential workflow. Results of the model have been used to improve understanding of the areal reservoir limits, enhance OOIP estimates, and optimize the development strategy.

Method

Incorporating the depositional, diagenetic, and tectonic factors in a reservoir model can be achieved by addressing them independently and then building them into the model following the interpreted geologic development of the reservoir. Core and wireline log data have been utilized to identify and model the depositional facies in the reservoir using multi-point facies simulation (MPFS). Optimal reservoir trends generated from mapping and seismic attributes have been applied to the petrophysical properties that have been seeded into the facies model, giving a further subdivision into reservoir units. Zones of higher fracture intensity are interpreted from seismic attributes and then input into the model as local permeability and porosity enhancements based on the attribute distribution. Since each element is handled independently, uncertainty and sensitivity workflows can be applied to each element in the sequence to determine the relative impact each step of the interpretation has on a volumetric ranking criteria. Final calibration of the model parameters is then done using dynamic flow simulation and history match analysis.

Example

This modeling approach has yielded a high resolution static model for the Freda Lake, Skinner Lake, and Neptune pools. It has been shown that MPFS modeling was able to honor the epeiric ramp depositional model, preserving interpreted facies distributions and relationships. Using history match analysis, porosity and permeability values have been fine-tuned using the diagentic and tectonic trends and modifiers. With a validated model a much improved understanding of the areal extent of the reservoir and associated uncertainty in reservoir properties has been reached. This has allowed for an improved assessment of OOIP across the pools and helped define the capacity for the development program. The model is actively being used to optimize development scenarios for the future.

Conclusions

By sub-dividing the elements that affect the reservoir, their relative impact and sensitivities on volumetric and simulation performance can be independently modified and analyzed. This has yielded a high-confidence reservoir model that has been used to improve the understanding of areal limits and improve OOIP calculations.