Reviving a Mature, Watered-Out Fractured Carbonate Reservoir: An Integrated Approach to Designing a Miscible EOR Scheme for the Bigoray Field in Alberta

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Bigoray Area of the Pembina Field

2 of about 50 naturally-fractured Devonian reefs in the Nisku formation in Alberta, Canada

Production started in 1978
Waterflooding started in 1979

Project Phases

- Phase I – Reservoir Characterization: Petrophysical and Geological Study
- Phase II – Geomodelling: Static reservoir model (reservoir geometry/properties)
- Phase III – Numerical Reservoir Simulation
Multidisciplinary Integrated Approach

The outcome of each discipline affects the input of the other disciplines.
Petrophysical Analysis

ELAN analysis provided a discrete facies distribution and characterization. Petrophysical model consistent with core analysis and poro/perm measurements.
Geological Analysis

Complex triple porosity system: matrix, fractures and vugs
Core evaluation correlated to spectral analysis
Image logs used to obtain fracture intensity/spacing and orientation
Seismic Analysis

3D seismic program was reinterpreted and combined with petrophysics derived well tops to obtain an updated geometry of the reefs.
Seismic Analysis

Ant tracking seismic attributes improved the definition of internal structure. Fracture intensity from image logs was correlated with an ant tracking seismic attribute and was propagated into a discrete fracture network (DFN).
Geomodelling

Seismic-driven structure
Geostatistically-distributed properties
Dynamic Modelling / History-matching

A dual-porosity/dual-permeability DP/DP model

Model reproduces 40 years of production/water injection

Oil, water and gas rates as well as pressures and breakthrough times are matched to historical observations
History-matching

Static model was iteratively updated until the appropriate reservoir connectivity was established to honor historical production/injection.

Initial model, poor history match

Final model, reasonable history match
History-matching

Final field-wide match

Field, Oil production rate

Field, Water production rate
Forecasting Optimization

1D solvent injection runs
2D solvent/chase gas runs
Optimize solvent scheduling, production and injection rates and controls
Solvent Injection Forecasting

Oil viscosity – liquid solvent injection (2021)
Solvent Injection Forecasting

Gas saturation – chase gas injection (2029)
Solvent Injection Forecasting

Gas saturation – blowdown period (2032)
Solvent Injection Forecasting

Gas saturation – blowdown period (2035)
Solvent Injection Forecasting

Gas saturation – blowdown period (2038)
Solvent Injection Forecasting

Gas saturation – blowdown period (2042)
Solvent Injection Forecasting

Optimized field-wide predicted incremental oil recovery

Cumulative Oil Production

- End of solvent/gas injection
- Start of blowdown
- 2x recovery
- End of waterflooding
- Start of solvent/gas injection
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